APPENDIX H

ADVANCE

**Advanced Driver and Vehicle
Advisory Navigation Concept**

Evaluation of Arterial Probe Vehicle,
Fixed Detector and Expressway Fixed Detector
Incident Detection Algorithm
Evaluation Report
Document # 8461 .01

Prepared by
Northwestern University Transportation Center

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ADVANCE

**Advance Driver and Vehicle
Advisory Navigation Concept**

EVALUATION OF ARTERIAL PROBE VEHICLE, FIXED DETECTOR AND EXPRESSWAY FIXED DETECTOR INCIDENT DETECTION ALGORITHM

by

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FINAL REPORT

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Executive Summary

The incident detection component of *ADVANCE* was developed to provide real time information about the presence of incidents and their location with the expectation that such information will be valuable to local drivers, the primary users of *ADVANCE* who are familiar with the network and have some knowledge of expected travel times under "normal conditions". Effective identification of incidents and provision of relevant information to drivers will substantially enhance the effectiveness of dynamic route guidance. This report describes the procedures and results of testing the effectiveness of arterial probe vehicle and fixed detector incident detection methods implemented in **ADVANCE** and expressway fixed detector incident detection methods considered for but not implemented in **ADVANCE.**

The *ADVANCE* incident detection system for arterial roads uses fixed detectors which provide occupancy and volume data, probe vehicles which provide link traversal data and anecdotal descriptions of events which are likely to impact traffic flow on arterial roads. For the purpose of evaluation, the anecdotal data provided by Northwest Central Dispatch (NWCD) is adopted as representing the true incident conditions of roadways in the portion of the *ADVANCE* area which is within the emergency service jurisdictions supported by NWCD. The evaluation of both fixed detector and probe vehicle algorithms is undertaken by measuring the extent to which each of these algorithms is able to identify incidents reported by NWCD and the extent to which it reports the presence of incidents which are not confirmed by NWCD.

The arterial fixed detector algorithm implemented in **ADVANCE** identified seven of 141 incidents reported during a two month period, while also reporting nine false alarms; the mean

time to detect the detected incidents was approximately five minutes after the first report received by local emergency services through Northwest Central Dispatch.   A modified algorithm which included standardized versions of volume deviation and occupancy deviation increased the number of detections to 29 with no false alarms and reduced the mean time to detect.

The arterial probe vehicle algorithm implemented in *ADVANCE* was evaluated for algorithms based on a single probe report and on multiple probe reports. The evaluation indicates that probe vehicle incident detection should be based on the use of multiple reports to avoid the potential for numerous false alarms based on unusual readings from a single vehicle caused by reasons other than disruptions in traffic flow. The algorithm based on the use of three sequential probe reports identified six of eleven incidents, for which sequences of three reports were available, without any false alarms.   An alternative algorithm which changed the specification by the addition of congestion distance deviation improved the results to detect nine of nine incidents which included suitable data for estimation without generating any false alarms.

These results indicate substantial potential for the development of arterial incident detection algorithms based on volume and occupancy data from fixed detectors and link traversal data from probe vehicles. Further development of this potential would require additional testing in a variety of traffic situations.

Evaluation of a limited implementation of an expressway incident detection algorithm resulted in incident detection and false alarm performance worse than that obtained in the development context.   This result raises questions about the use of previously estimated expressway incident detection algorithms without new estimation in the application area.

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1. INTRODUCTION

1.1   Objective of Incident Detection

An important objective of the *ADVANCE* Project is to provide participating drivers with real-time route planning information, based on up-to-date travel times on the links in the *ADVANCE* area. Since most drivers will be local residents, with considerable knowledge about the local network and information about recurring congestion; navigational guidance based on historic values of travel time will be of limited value. Incidents, on the contrary, are non-recurring events on the network which can have significant impacts, which cannot be anticipated by drivers, on link travel times.   Thus, real-time information, regarding the occurrence of incidents and their location, will be valuable even to those travelers who are familiar with the network and have some knowledge of expected travel times under "normal conditions." The effectiveness of the *ADVANCE* incident detection algorithm and its successors has the potential to enhance the effectiveness of dynamic route guidance both for ATIS users and others.

1.2   Multiple Data Sources for Arterial Incident Detection

The *ADVANCE* incident detection system for arterial roads uses three sources of information to identify incident conditions on the network. These include: (1) fixed detectors which provide occupancy and volume data averaged over a limited time period for specific sections of selected network links, (2) probe vehicles which travel freely on the network and report link travel times, and (3) anecdotal reports of particular events affecting traffic flow provided by people traveling on or monitoring the road network.

Fixed detectors provide a continuous stream of volume and occupancy data aggregated

over **a** certain time interval (e.g., every five minutes) across all lanes at a limited number of fixed locations'. Probe vehicles and anecdotal sources provide data intermittently at locations determined by the location of the probe equipped vehicle or the reporting source, respectively. Specifically, probe vehicles will provide travel time for links when they complete traversals of those links. During any time interval, probe reports will be available for only a small number of links due to the small number of probe vehicles traversing the network during a given time interval. Similarly, anecdotal data will be available only when emergency personnel or motorists report a traffic incident on the link.

1.3   Expressway Incident Detection

A more limited incident detection capability for expressways in the *ADVANCE* and adjacent areas is based on estimation of the California incident detection algorithm with data from fixed detectors which are located at approximately one-half mile intervals for the center lane of express roadway (Koppelman and Lin, 1996)[2].

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[1]   The fixed detectors in the *ADVANCE* area are part of the traffic signal control system. Detectors located on Dundee Road between Milwaukee Avenue and Rand Road are generally located approximately 90 meters upstream from signalized intersections. Detectors at 26 locations are linked to the *ADVANCE* Traffic Information Center (TIC) and provide information on volume (total across lanes) and occupancy (average across lanes) for each five minute period.

[2]   Expressway detectors are linked to the Traffic System Center of the Illinois DOT and volume and occupancy data for each one minute interval is forwarded to the *ADVANCE* TIC.

1.4   Purpose and Scope

The purpose of this report is to evaluate the performance of the automatic incident detection algorithms for arterial roads (probe vehicle, fixed detector, and fused) and for expressways. The evaluation of the arterial fixed detector algorithm is undertaken by collecting data from loop detectors along Dundee Road and from NWCD logs[3] for incident verification. Evaluation of the probe vehicle algorithm is based on data which is collected through the assignment of a fleet of vehicles to travel on incident links to acquire current travel time and related information for these links under incident and non-incident conditions[4] and incident reports from NWCD logs. Evaluation of the fused algorithm was to be based on loop detector, probe vehicle and NWCD incident data along Dundee Road. However, this evaluation could not be completed due to the absence of incidents along this portion of Dundee Road on dates when probe vehicles were assigned to incident detection evaluation.   Evaluation of the expressway incident detection algorithm is undertaken by collecting automatic data from loop detectors along an expressway and comparing it to incident data based on cellular phone and Emergency Traffic Patrol reports[5.]   The incident detection evaluation uses these data to calculate

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[3]   Northwest Central Dispatch (NWCD) transmitted all traffic related emergency reports on roadways in their jurisdiction which covers approximately one-half of the *ADVANCE* test area to the *ADVANCE* TIC.   Twenty-two of the Dundee Road detector stations are in the NWCD area.

[4]   Incident conditions are monitored by assigning vehicles to links on which incidents are reported; non-incident conditions are monitored by assigning vehicles to the same links on subsequent days. The planned use of data from traversals under construction (pseudo incident) and non-construction conditions was not undertaken as construction projects on these links continued through the entire data collection period.

[5]   The interpretation of cellular phone (*999) and Emergency Traffic Patrol Reports is described in Task Report TRF-ID-311/312 (Koppelman and Lin, 1996).

incident detection and false alarm rates for each incident detection algorithm.

Additional analysis is undertaken to determine the extent to which modifications to the implemented arterial algorithms will improve their performance.

1.5   Report Structure

The remainder of this report is organized as follows.   The algorithms for arterial fixed detector, arterial probe vehicle and expressway are discussed and analyzed in Sections 2, 3 and 4, respectively. Each section describes the logic of the algorithm and the **type of** data used, then presents the evaluation and, as appropriate, modification of the specific algorithm. Finally, the implementation and algorithm description are presented.   Section 5 summarizes the overall results.

2. FIXED DETECTOR ALGORITHM

2.1   Overview

2.1.1 Concept

An incident which impacts traffic flow is expected to increase occupancy[6] upstream and decrease occupancy downstream from the incident and to reduce the flow rate (volume) both upstream and downstream of the incident. Further, average speed is likely to decrease upstream of the incident due to increased congestion. The changes in volume and occupancy are directly measurable at detectors located upstream and downstream of the incident provided that the distance between the incident location and the detectors is limited. Speed effects can be estimated indirectly by the ratio of volume to occupancy, which is positively related to the speed[7].

The arterial fixed detector algorithm compares current detector readings to historic average values for the corresponding day type and time period to identify differences in traffic flow conditions. Current occupancies and volumes are reported from detectors at 22 locations in the Dundee Rd. corridor at the end of each five minute period. The historic occupancies and volumes for each detector are the average value recorded at the detector, under normal traffic flow conditions', for the corresponding time period and day type'.

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[6] Occupancy is the percentage of time that the space above the detector is occupied by a vehicle.

[7] The relationship between this ratio and speed is likely to be monotonic but non-linear on arterial links (Berka et ul., 1995).

[8] Normal conditions are when there is no incident on the roadway.

[9] Day type consists of four categories: Monday through Thursday, Friday, Saturday and Sunday.

Variables based on current volume and occupancy and their relationship to historic volume and occupancy were formulated and tested to select a preferred model based on fixed detector data under simulated incident and non-incident conditions. The measures considered include the following variables collected at both the upstream and downstream detector stations:

1) Occupancy Deviation (OCCDEV):   Deviation of occupancy from its historic value, OCCOBS - OCCMEAN;

2) Volume Deviation (VOLDEV):   Deviation of volume from its historic value, VOLOBS - VOLMEAN;

3) Occupancy Ratio (OCCRAT):   Ratio of occupancy to its historic value, OCCOBS / OCCMEAN;

4) Volume Ratio (VOLRAT):   Ratio of volume to its historic value, VOLOBS / VOLMEAN;

5) Deviation of Volume by Occupancy Ratio (VBYODEV):   Deviation of volume by occupancy from historic value, VBYO-OBS - VBYOMEAN;

6) Ratio of Volume by Occupancy Ratio (VBYORAT):   Ratio of volume by occupancy to historic value, VBYO-OBS / VBYOMEAN.

where,

OCCOBS:	observed occupancy,
OCCMEAN:	historic occupancy",
VOLOBS:	observed volume,
VOLMEAN:	historic volume, and
VBYO-OBS:	observed ratio of volume by occupancy.
VBYOMEAN:	historic ratio of volume by occupancy.

The estimation approach for the arterial incident detection algorithm was described in Sethi *et al.* (1995) as follows: "Models were estimated using discriminant analysis (Klecka,

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[10] The historic values for occupancy, volume and volume by occupancy are obtained by averaging values for non-incident periods for corresponding time periods and day types.

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1980) in which a linear combination of variables is used to classify cases into two mutually exclusive groups, incident and non-incident conditions. The models were calibrated using cases for which the group membership was known. In discriminant analysis, the coefficients are estimated so that the 'values of the discriminant function differ.. as much as possible between the groups' (Norusis, 1988). Classification using discriminant analysis is dependent on a discriminant score, which is a function of the measured variables and the prior probability of an accident. The prior probabilities reflect the expected share of observations (time periods on a link) during which an incident is likely to occur. "

The model with the best performance in terms of the detection rate and false alarm rate included the occupancy deviation and the volume by occupancy deviation, both measured at the upstream detector station (Koppelman *et al.,* 1994). These variables are used to compute a discriminant score (Green, 1979). If the score exceeds zero, the fixed detector algorithm classifies the condition as an incident on the section of the roadway associated with the detector.

2.1.2 Initial Field Testing

An initial field test was based on fixed detector data only since the incident confirmation data from NWCD was not available. The lack of confirmed incident reports precluded re-calibration of the fixed detector algorithm (Bhandari *et al.* 1995). However, the fixed detector data was used to examine the performance of the fixed detector algorithm under apparent non-incident conditions.

The fixed detector data covered most of the five minute time periods from November 20, 1994 to February 1, 1995. The algorithm generated 814 incident alarms, all of which were

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presumed to be false alarms" from 5 1,455 detector reports (detectorized links by time period).

An investigation of this data led to the adoption of the following heuristic rules which eliminated

all these alarms:

- An incident is not declared if current occupancy is below a predefined threshold. This

  threshold occupancy level is set at 20%, when travel time is virtually independent of

  occupancy (Sisiopiku *et al.,* 1994).

- An incident is not declared if the flow volume is greater than its historic value

  (independent of the occupancy level).

- An incident is not declared if the flow volume is greater than 60 vehicles per 5

  minutes per lane (i.e., 720 vehicles per hour per lane).

  A discriminant score, FD_DISC_FUNC, is computed as follows :

  $$FD\_DISC\_FUNC = \beta_0 + \beta_1 * OCCDEV + \beta_2 * OCCRAT + \beta_3 * VOLDEV + \beta_4 * VOLRAT + \beta_5 * VBYODEV + \beta_6 * VBYORAT$$

where the modified model parameters are:

$\beta_0 =$ -14.880,
$\beta_1 =$ 0.0192,
$\beta_2 =$ 0.0^{12},
$\beta_3 =$ 0.0,
$\beta_4 =$ 0.0,
$\beta_5 =$ -4.088,
$\beta_6 =$ 0.0.

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[11] In the absence of confirmed incident reports, it was assumed that there were no incidents during the time periods corresponding to the detector data used for testing. The large number of incident reports indicated that this assumption was correct for most, if not all, incident identifications. Assuming all were false alarms resulted in an algorithm which is conservative; that is, it will identify a relatively small number of incidents which produce large travel flow impacts while generating very few false alarms.

[12] Inclusion of variables with zero weight allows the function to be modified easily to include additional variables by changing the weight to a non-zero value.

If the discriminant score is greater than 0, an incident is flagged for the link associated with the detector for the corresponding time period; if the discriminant score is less than 0, normal conditions are assumed.

2.1.3 Fixed Detector Calibration

Initial field calibration was undertaken based on fixed detector data for the period from April 28th, through June 29th, 1995, and incident data in the Dundee Rd. corridor reported by NWCD (Koppelman and Tsai 1995). During this period, 50 incidents were reported in the Dundee Rd. corridor. Of these, 37 incidents were excluded because they occurred during periods when fixed detector data was not available or the detector data was well within the normal range at that location. The remaining 13 incidents generated 276 incident observations (detector locations by time period) out of 270,084 detector reports (detector locations by time period).

Model estimations were undertaken with variables defined in section 2.1.1. Based on the results, the fixed detector algorithm was modified by adjusting the screening rule for volume from 60 to 70 vehicles per lane per five minutes and modifying the coefficients to:

$$\beta_0 = -14.880,$$
$$\beta_1 = 0.0192,$$
$$\beta_2 = 0.0^{12},$$
$$\beta_3 = 0.0,$$
$$\beta_4 = 0.0,$$
$$\beta_5 = -4.088,$$
$$\beta_6 = 0.0.$$

With this modification, volume deviation (VOLDEV) at the upstream detector is added to the algorithm.

2.2   Field Data Collection for Evaluation

2.2.1 Data Description

The evaluation of the fixed detector algorithm uses the Dundee Rd. detector data and the NWCD incident records. These data were logged on a daily basis from October 1st, through November 30th, 1995. Fixed detector data are often missing in the early morning hours and sometimes during other time periods for a variety of reasons including malfunction of loop detectors.

The NWCD reports include information regarding incident location, received time (initial incident report) and clear time (incident termination) and incident type. The incident start time is set at 30 minutes before the first report received on the possibility that there may be a delay in reporting the incident.   The rule for selection of the incident start time is arbitrary.   Data which includes true incident start times, based on driver reports, and time of the first NWCD incident report would be required to provide a non-arbitrary basis for selecting incident start time[13]. A change in the incident start time will cause a corresponding change in the mean time to detect. That is, the assumption of later (earlier) start times will reduce (increase) the mean time to detect. The end time is set at 15 minutes after the clear time of the report because it is possible that the police or fire department units clear (depart from the incident location) before traffic flow returns to normal. The selection of incident end time is arbitrary but has no impact on any of the performance measures included in the evaluation.   Most of the incident reports do not include information about the direction of the incident lanes.   In addition, the incident

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[13] Collection of this information requires continuous monitoring of the roadway by observers or closed circuit televisions.

location is given in terms of a recognized reference point (usually an intersection) but without direction and distance to the incident site so the exact incident location is generally not known. We adopt the convention that the incident is in the vicinity of the reported location and attempt to detect the incident at all detector stations upstream from that location on any adjacent link.

During the evaluation test period, 151 incidents were reported in this portion of Dundee Road. Ten incidents were excluded because they occurred during periods when fixed detector data was not available at the incident location. The remaining 141 incidents generated 4,439 incident observations (detector locations by time period) out of 289,161 detector reports (detector locations by time period).

Incidents are classified into three categories: (1) accident-- includes accident with property damage or injuries, activated fire alarms, and hazardous material spills; (2) law enforcement-- includes traffic stop and arrest, suspended driver's license, and motorist assistance; and (3) other-- includes hit and run with property damage, ambulance calls and light malfunction. Of these incidents, about half are considered minor incidents (law enforcement) which have little impact on traffic flow and are expected to be difficult to detect (see Table 2.1).

Table 2.1 Incident Type and Duration Analyses

Incident Type		Cases	Average Duration (minutes)
Law Enforcement	Traffic Stop	48	22.3
	Traffic Arrest	2	62.5
	Suspended Driver License	1	35.0
	Motorist Assistance	19	25.3
Accident	Accident with Property Damage	27	45.9
	Accident with Injuries	14	41.8
	Activated Fire Alarm	8	23.1
	Hazard Material Spill	1	10.0
Others	Light Malfunction	3	23.3
	Ambulance Call	12	28.3
	Hit and Run with Property Damage	2	77.5
	Other	4	23.8
Total		141	31.3

2.2.2 Preliminary Analysis

The time-of-day distribution of average volume and occupancy for two stations, westbound at Wilke Road and Eastbound at Buffalo Grove, are given in Figures 2.1 and 2.2, respectively. The figures show that (1) the volume and occupancy patterns differ greatly by location and flow direction and (2) there is considerable variation in volume and occupancy by time of day, especially for afternoon peak periods in the eastbound direction. These results imply that there is a need to compute historic average value of occupancy and volume separately

for each station and time of day.

The average volume and occupancy of each station during weekday peak periods[14], under incident and non-incident conditions, are given in Table 2.2. The results show that average occupancy is higher during incident periods at every station and that average volume is lower at ten of the thirteen stations where incidents occurred. Incidents which result in volume increase are likely to be more difficult detect than incidents which follow the expected pattern; increase in occupancy and decrease in volume.

Figure 2.3 shows the distribution of deviation of volume and occupancy (current values minus historic values), for both incident and non-incident periods (because of the large number of non-incident periods, only 1% of these are included). The deviation values of more than half of the incidents are within the range of values commonly observed during non-incident periods. A more detailed view of these data for values of occupancy deviation greater than ten including fifty percent of non-incident periods indicates that very few incidents can be distinguished from non-incident data if the model is based exclusively on occupancy and volume deviation (Figure 2.4). This indicates that unless the algorithm incorporates other variables, large numbers of false alarms will be generated in any effort to detect more than a small fraction of incidents.

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[14] The data in this table is for peak periods, 6:00-9:00am and 4:00-7:00pm, to control for time of day variability. 40 of the 141 incidents occur during peak periods.
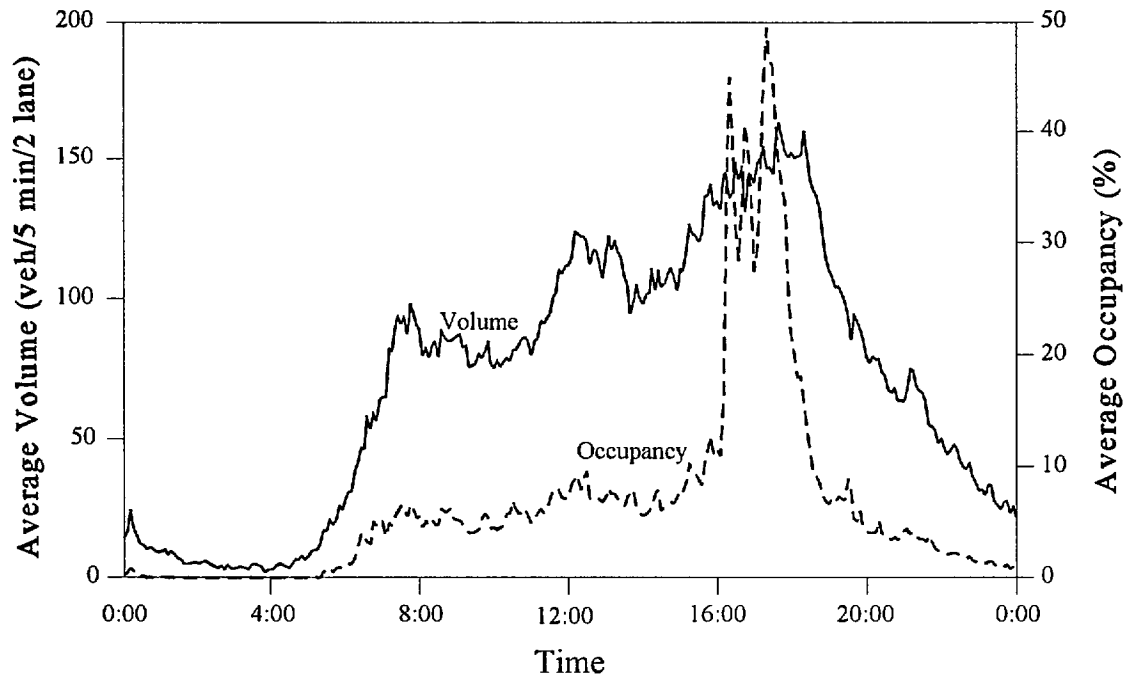
Figure 2.1 Average Volume and Occupancy for Detectors at Wilke Rd, Westbound on Dundee
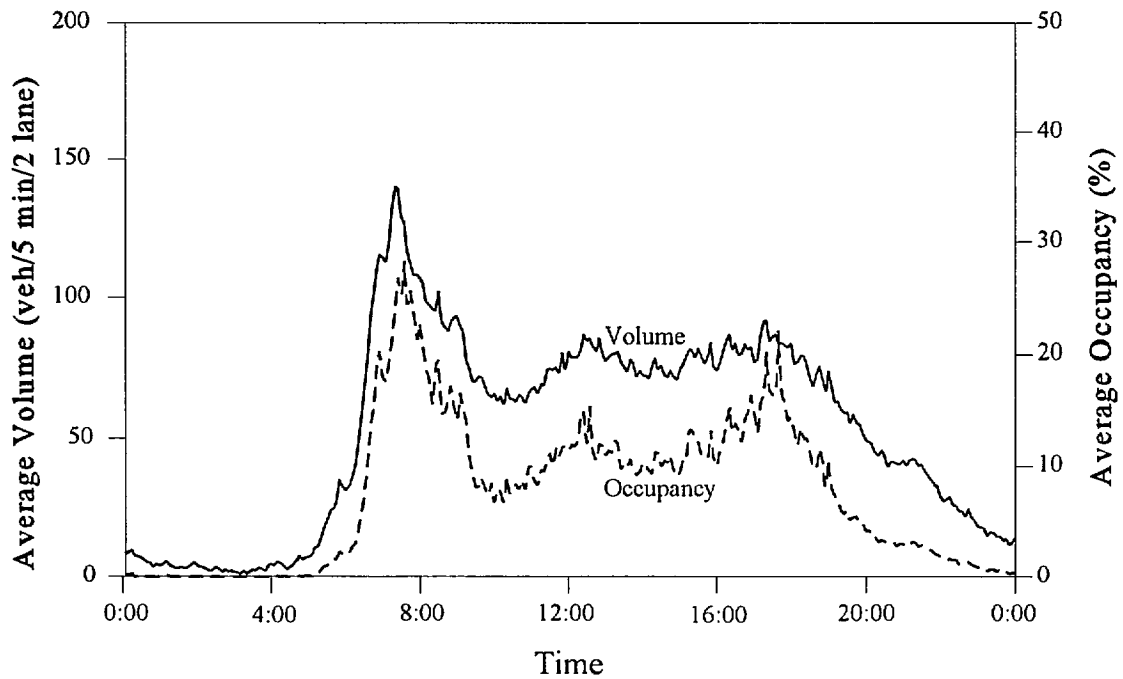
Figure 2.2 Average Volume and Occupancy for Detectors at Buffalo Grove, Eastbound on Dundee

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Table 2.2 Average Volume and Occupancy for Weekday Peak Periods (by detectors)

Detector Station			Incident Data			Non-Incident Data	
Master No.	Detector	Location, Direction	No of Incident	Volume	Occupancy	Volume	Occupancy
	13,14	E. Frontage, EB	5	119.20	35.80	148.06	11.56
	15,16	E. Frontage, WB	3	81.66	51.00	115.04	17.86
	17,18	Baldwin, EB	5	45.20	35.20	74.67	15.26
	1,2	Arlington Hts, EB	4	85.50	7.00	102.96	5.49
	19,20	Crofton, EB	0			43.85	3.06
	21,22	Arlington Hts, WB	0			83.73	11.80
	23,24	Arlington Hts, NB	3	64.67	53.67	65.42	17.13
	25,26	Arlington Hts, SB	1	50.00	32.00	57.93	10.63
	3,4	W. Frontage, WB	4	138.50	27.00	108.50	8.69
	7,8	IL53 E. Ramp, EB	1	51.00	7.00	76.77	6.41
	9,10,11	IL53 E. Ramp, NB	0			95.20	18.28
	11,12	Buffalo Grove, SB	1	44.00	15.00	52.32	14.45
	13,14	Lake, WB	0			99.17	12.24
	15,16	IL83, EB	0			92.43	16.85
	17,18	IL83, WB	0			75.58	11.85
	19,20	IL83, NB	0			74.78	9.85
2	1,2	Golfview, EB	0			112.33	6.27
	21,22	IL83, SB	0			48.83	8.79
	3,4	Golfview, WB	6	92.33	7.83	102.62	5.96
	5,6	Buffalo Grove, EB	3	86.33	23.66	88.02	15.35
	7,8	Buffalo Grove, WB	2	114.50	39.50	93.04	16.37
	9,10	Buffalo Grove, NB	2	66.50	53.00	45.87	8.76
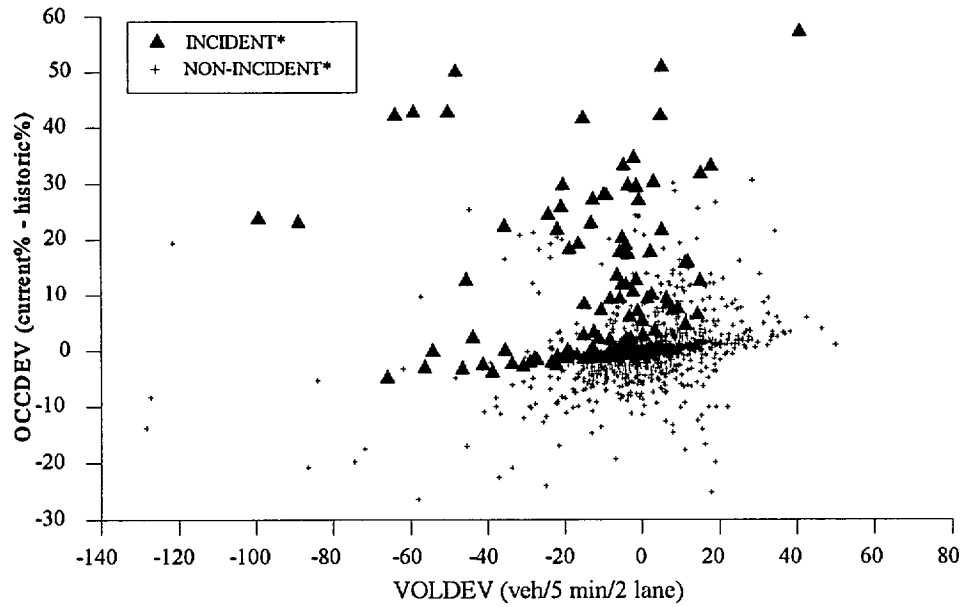
Figure 2.3 Occupancy Deviation and Volume Deviation for Incident and Non-incident Cases
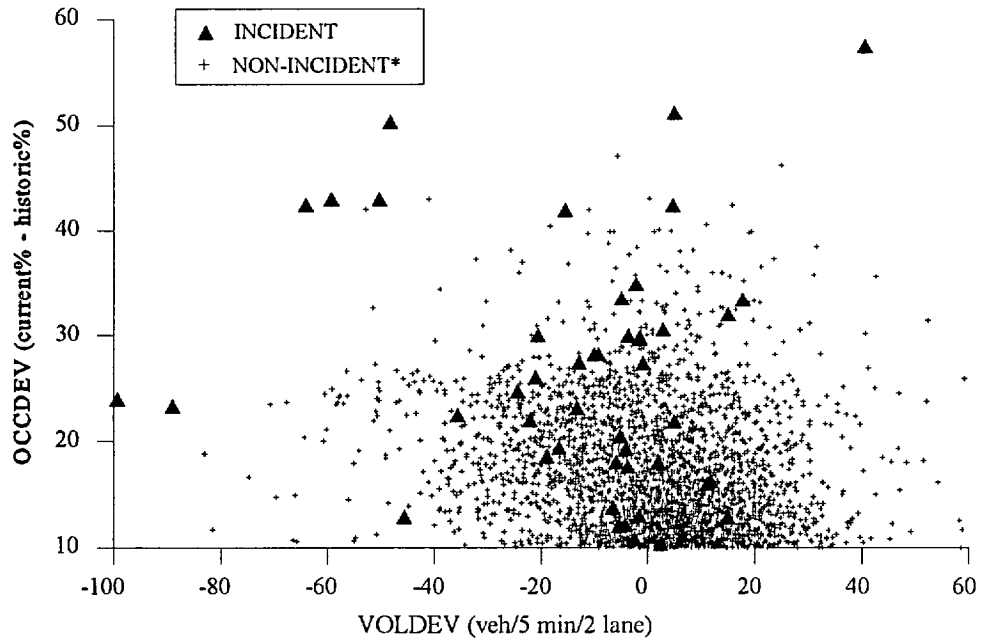
Figure 2.4 Occupancy Deviation and Volume Deviation for Incident and Non-incident Cases with Increased Detail in Critical Range

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2.3   Evaluation Results

2.3.1 Overview

The performance of the fixed detector incident detection algorithm is evaluated by the number of incidents detected, the number of false alarms and the mean time to detect an incident. Initial evaluation is based on all incidents for which fixed detector and incident validation data is available using the implemented algorithm which was based on initial field data (Section 2.1.3). Further evaluation is performed incorporating screening rules which were developed based on limited field data.   Three sets of screening rules are examined to see if any of them improve the overall level of algorithm performance by decreasing false alarms while maintaining incident detection.

Additional evaluation was undertaken to consider the extent to which the performance results are influenced by the time of day or the incident types considered.   Incident detection is expected to be better during peak (heavy travel) time periods because it is during these time periods that a loss of roadway capacity is likely to have the greatest impact on traffic flow characteristics. This additional evaluation is undertaken by splitting the data into peak periods defined as 6:00am to 9:00am and   4:00pm to 7:00pm, Monday through Friday, and all other time periods. Also, it is expected that more severe incidents (e.g., accident with injuries) are likely to have a more substantial impact on traffic flow than other incidents (e.g., traffic arrest). Therefore, they will be easier to distinguish from normal traffic conditions than other incident types. The effect of differentiating incident types (accident and other vs. law enforcement) on incident detection will be explored.

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2.3.2 Overall Evaluation

An overall evaluation is undertaken with the variables and parameters defined in Section 2.1.3 for all reported incidents. Table 2.3, reports that 7 out of 141 incidents are detected with a mean time to detect of 35 minutes (or 5 minutes after the first NWCD report). The low incident detection rate is due, in part, to the fact that most of the incidents are minor incidents or incidents occurring during off-peak periods: 70 are minor incidents including traffic stop, traffic arrest, and motorist assistance and 101 incidents occur during off-peak periods; only 26 incidents are major incidents occurring during peak periods". On the other hand, 9 false alarms are declared by the model. Although this number is low, it is greater than the number of detected incidents.

Table 2.3 Initial Evaluation Results of Fixed Detector Incident Detection Model

Number of Incidents	Number of Detected Incidents	Number of Detected Incident Periods	Number of False Alarms	Mean Time to Detect (min .)
141	7	32	9	35.0

An interesting result is that none of the incidents detected are in the area covered by master[16] 92. For unknown reasons, the incident data for detectors linked to master 92 are less distinct from non-incident data than for detectors linked to master 1 (see Table 2.2). It is particularly surprising that of the four Master 92 detector stations where incidents were reported,

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[15] Differences in detection by time period and incident type are examined in Sections 2.3.4 and 2.3.5, respectively.

[16] Fixed detector data is initially routed to a Master Controller which manages signal progression for multiple intersections. There are two master controllers in this section of Dundee Road, Master 92 and Master 1.

volume does not decrease as expected in some cases (volumes are higher during incident periods than non-incident periods for two cases and about the same for another case).

2.3.3 Evaluation with Heuristic Screening Rules

A variety of screening rules were proposed to reduce the number of false alarms generated during initial field testing with the objective of not substantially reducing the number of incidents detected. Three distinct screening rules are evaluated as shown in Table 2.4. These rules include only those time periods for which:

·   Volume **is** less than or equal to 70 vehicles per lane per 5 minutes.

·   Current volume is less than its historic average and current occupancy is greater than 20%.

·   Current occupancy is greater than 20% and occupancy temporal difference (OCCTD, current occupancy minus occupancy 5 minutes ago) is greater than 5%.

Table 2.4 The Effect of Heuristic Rules on the Incident Detection

Screening Rules	No. of Incidents which Satisfy Screening Rule(s)	No. of Detected Incidents	No. of Detected Incident Periods	No. of False Alarms
Vol ≤ 70	140	5	28	9
Vol $\leq$ His-vol **and Occ$\geq$20%**	45	7	23	9
Occ $\geq$20% and Occtd ≤ 5 %	45	4	10	5
No Screening	141	7	32	9

Only the third screening rule reduces the number of false alarms and that rule reduces the number of incidents detected by a similar fraction. The other rules reduce the number of incidents detected without reducing the number of false alarms. That is, the proposed screening rules are equally or more likely to reduce incident detection than to reduce false alarms. Such screening rules do not provide a satisfactory approach to improving incident detection results.

2.3.4 Evaluation by Time of Day

The evaluation results by peak and off-peak periods are reported in Table 2.5. The peak period results are better than the off-peak period results. Although less than one-third of incidents occur during peak periods, most detected incidents (6 out of 7) are during peak periods. Two factors appear to contribute to poor incident detection during off-peak periods. First, more than half of all incidents during off-peak periods (56 out of 101) are minor incidents (traffic stop, traffic arrest, and motor assistance) which are more difficult to detect than the others. Second, the level of congestion is lower during off-peak periods so incidents which **occur** during these periods are likely to have a much smaller impact on traffic flow than those which occur during peak periods.

Table 2.5 Effect of Peak vs. Off-Peak Periods on Incident Detection

	No. of Incidents	No. of Detected Incidents	No. of Detected Incident Periods	No. of False Alarms
Peak	40	6	28	9
Off-Peak	101	1	4	0
Pooled Data	141	7	32	9

2.3.5 Evaluation by Incident Type

Table 2.6 shows the evaluation results by incident type. All the incidents detected are either "accidents" or "other" (not law enforcement related incidents). This indicates that law enforcement incidents, most of which are undertaken in a manner to minimize the impact on traffic flow, are likely to be difficult to detect and consideration should be given to estimating an incident detection algorithm using data which excludes these incidents. The remaining categories (accident and other) have similar detection results (4 out of 50 accidents; 3 out of 21 other incidents).

Table 2.6 Comparison of Detection Effectiveness by Incident Categories

Incident Category	No. of Incidents	No. of Detected Incidents	No. of Detected Incident Periods
Accident	50	4	16
Law Enforcement	70	0	0
Others	21	3	16
All Incidents	141	7	32

2.3.6 Summary

The overall evaluation results are less than satisfactory. Only 7 of 141 incidents were detected. The number of false alarms is larger than the number of detected incidents. One **of** the reasons for this poor performance of the algorithm is that about 70% of total incidents occurred during off-peak periods and almost 50% of total incidents are minor.

The inclusion of heuristic screening rules does not have a positive effect on the incident detection. The evaluation results by time of day and incident types indicate that the algorithm performs best when (1) it is applied to peak periods and (2) for detection of other than law enforcement incidents.

The following section explores alternative approaches for enhancing the performance of the algorithm.

2.4   Modifications of Arterial Fixed Detector Incident Detection Algorithm

2.4.1 Re-calibration with Current Variables

Six current variables described in Section 2.1.1 are considered: occupancy deviation (OCCDEV); occupancy ratio (OCCRAT); volume deviation (VOLDEV); volume ratio (VOLRAT); volume by occupancy deviation (VBYODEV); and volume by occupancy ratio (VBYORAT).   Algorithm modifications with these variables were undertaken using the evaluation data. Table 2.7 reports the discriminant parameters and classification results for different thresholds[17] for three preferred specifications among many considered.   Only model 3, with the same specification as the tested model, combined with a threshold of -5.0 is equal to **or** better than the tested model (Table 2.3); it detects the same number of incidents, detects more incident periods and generates fewer false alarms.   This result supports the selection of the tested specification (among the specifications based on the occupancy, volume and volume **by**

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[17] The thresholds are selected to illustrate a range of results with respect to incidents detected and false alarms.   The selection of a preferred threshold reflects judgement about the importance of reducing the number of false alarms at the cost of reducing the number of incidents detected.

occupancy variables). However, it also indicates the limitation of this specification to provide

an effective arterial incident detection algorithm.

Table 2.7 Fixed Detector Detection Discriminant Parameters and Classification Performance

Model 1				Model 2				Model 3			
OCCDEV	0.120			OCCDEV	0.140			OCCDEV	0.238		
OCCRAT	0.324			OCCRAT	0.308			OCCRAT			
VOLDEV				VOLDEV	-0.0371			VOLDEV	-0.0454		
VOLRAT				VOLRAT				VOLRAT			
VBYODEV	-0.0604			VBYODEV	-0.0509			VBYODEV	-0.0394		
VBYORAT				VBYORAT				VBYORAT			
CONSTANT	-12.913			CONSTANT	-11.630			CONSTANT	-15.824		
Threshold	False Alarms	Detected Incidents	Detected Incident Periods	Threshold	False Alarms	Detected Incidents	Detected Incident Periods	Threshold	False Alarms	Detected Incidents	Detected Incident Periods
0	1	5	9	0	6	5	9	0	1	0	0
-2.5	11	5	10	-1.5	16	6	12	-5.0	7	7	39
-3.0	16	6	11	-2.0	23	8	16	-5.5	22	8	49
-4.0	43	7	12	-3.0	43	11	36	-6.0	33	10	59
-5.0	101	10	19	-4.0	128	16	72	-7.0	95	10	30

2.4.2 Extended Specification with Additional Variables

Due to the poor performance of all the algorithms based on the original set of variables, further modification of the algorithm was undertaken. Three new variables, standardized versions of the original variables, were considered. In each case, the standardized variables are obtained by dividing the deviation variables in the preferred model by their historical standard deviation during non-incident periods for the corresponding time period and day type as follows:

SOCCDEV   = OCCDEV / SDOCCDEV

SVOLDEV   = OCCDEV / SDOCCDEV

SVBYODEV = OCCDEV / SDOCCDEV

where   SDxxxxxx is the standard deviation of the historic variable and

Sxxxxxx is the standardized value of the observed variable at the current time.

Thus, the standardized values measure deviations relative to the variability of each variable at different locations by time and day type[18].

The discriminant parameter estimates for the new model with standardized occupancy and volume deviation" and the original model (original specification with new parameters, model 3 in Table 2.7) are presented in Table 2.8 with classification results for a range of thresholds selected for each model. The standardized model obtains substantially better results. For a threshold of 1.2, it detects 29 incidents without any false alarms; while the original model could

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[18] To avoid unreasonably large values of SOCCDEV and SVOLDEV the minimum standard deviations for historical data are set at 0.5 % for occupancy deviation and 3 vehicles per minute per station for volume deviation.

[19] A similar model including standardized volume by occupancy deviation obtained very similar results to the model which includes only standardized volume and standardized occupancy deviation.

not detect any incidents without causing some false alarms and obtained a large number of false alarms to detect a much smaller number of incidents. This result indicates the desirability of adopting the standardized model for use in the identification of arterial incidents.

Table 2.8 Comparison of Models with Standardized Variables and with Original Variables

Original Model						Standardized Model					
OCCDEV		0.238				SOCCDEV		1.278			
VOLDEV		-0.0454				SVOLDEV		-0.724			
VBYODEV		-0.0394				CONSTANT		-7.729			
CONSTANT		-15.824									
Threshold	False Alarms	False Alarm Rate (%)	Detected Incidents	Detection Rate (%)	Detected Incident Periods	Threshold	False Alarms	False Alarm Rate (%)	Detected Incidents	Detection Rate (%)	Detected Incident Periods
0	1	0.0004	0	0	0	1.2	0	0	29	20.6	86
-5.0	7	0.0025	7	5.0	39	0.5	6	0.0021	32	22.7	93
-5.5	33	0.0116	10	7.1	59	0	30	0.0105	33	23.4	99
-6.0	51	0.0179	10	7.1	69	-0.5	76	0.0267	35	24.8	105
-7.0	95	0.0334	10	7.1	80	-1.0	106	0.0372	36	25.5	110
-7.5	168	0.0590	13	9.2	86	-1.5	151	0.0530	36	25.5	120

The mean time to detect the detected incidents for the selected threshold is 29.5 minutes from the first record or at approximately the same time as the first NWCD report. The number of incidents detected in each ten minute interval, shown in Table 2.9, indicates that some of these incidents would have been detected early enough to provide an earlier warning to NWCD and the emergency services it supports than that obtained using current sources.

Table 2.9 Time Period of Incident Detection Relative to Time Period of NWCD Report

Time Period	Earlier Time			NWCD Report	Later Time		
	20-30	10-20	0-10		0-10	10-20	20+
Number of Detections	7	2	5	1	6	3	5

The number of incidents and incident periods detected by incident type for the new model is shown in Table 2.10. These results are superior to the results of the original model (Table 2.6) in every category indicating an across the board improvement in incident detection. Further, these results are obtained with no false alarms rather than seven using the implemented model (Table 2.3).

Table 2.10 Detection Effectiveness by Incident Categories

Incident Category	No. of Incidents	No. of Detected Incidents	No. of Detected Incident Periods
Accident	50	12	41
Law Enforcement	70	11	28
Other	21	6	17
All Incidents	141	29	86

The sensitivity of these results to selection of the score threshold is illustrated in Figure 2.5 which shows the values of standardized occupancy and volume deviation for the highest score point for each incident and for all non-incident periods (close to the score threshold and
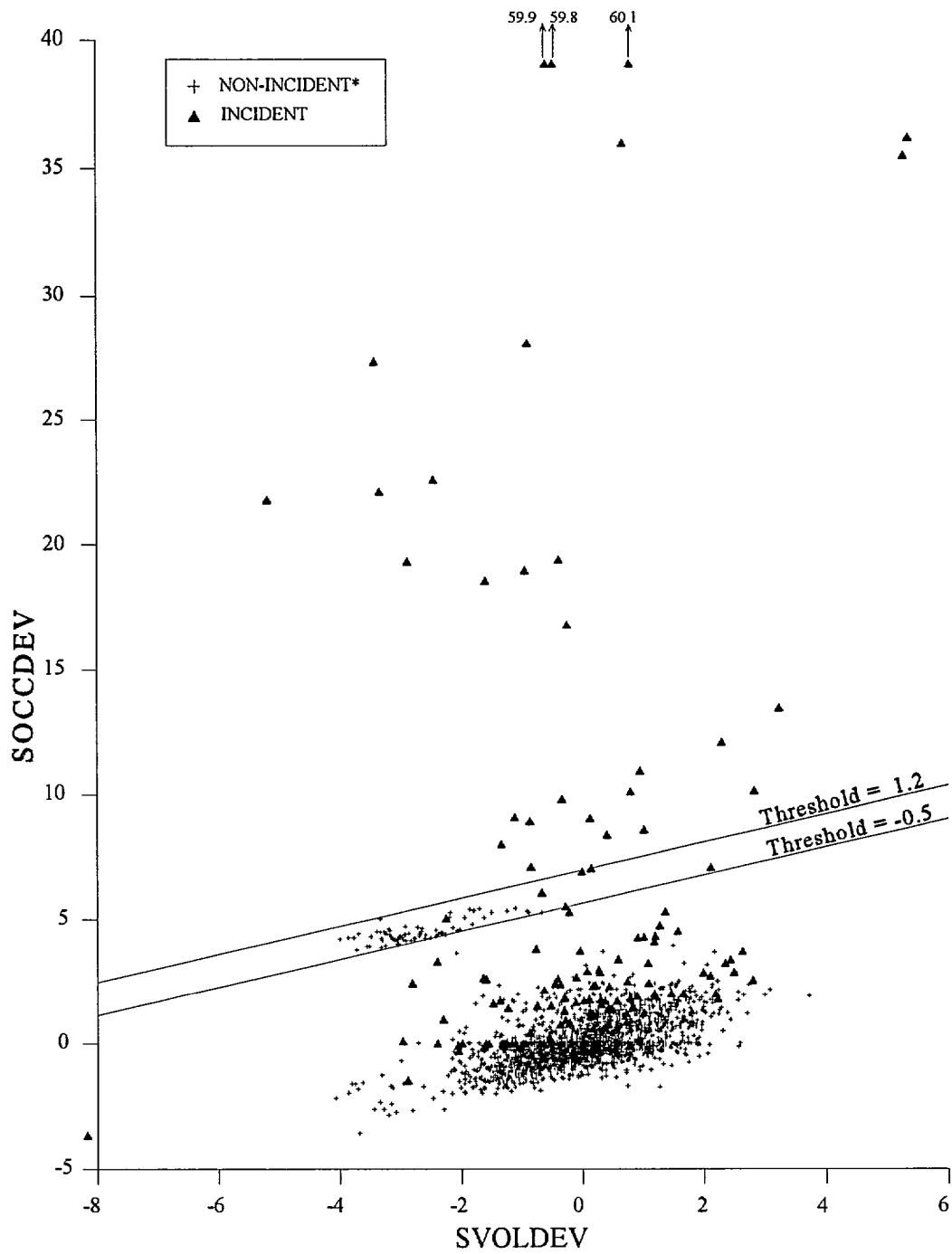
*Includes all non-incident observations above the line of threshold=-0.5 and 1% of non-incident observations below the threshold of -0.5.

Figure 2.5 Incident and Non-incident, Standardized Occupancy Deviation by Standardized Volume Deviation

percent of other non-incident periods). This figure demonstrates that a large fraction of incident observations are well within the data "cloud" for non-incident observations making these incidents "undetectable". Small changes in the threshold (e.g., from -0.5 to + 1.2) will screen out large numbers of false alarms.

2.4.3 Model Estimation for Peak and Off-peak Periods

Incidents occurring during peak periods are likely to have more serious impacts on traffic flow than incidents occurring during off-peak periods. The normal travel pattern in **peak** periods is also different from that in off-peak periods. Therefore, it may be appropriate to use different algorithm parameters during peak periods and off-peak periods. The discriminant parameters and the effect of threshold selection on the false alarm and detection numbers for pooled, peak, and off-peak models are shown in Table 2.11.

The estimation results for the parameters are very similar during peak and off-peak periods and the combined detection results for peak and off-peak models with no false alarms are very close to those for the pooled model; the number of detected incidents increases from 29 to 30 and the number of detected incident periods increases from 86 to 87. Further, the 29 incidents detected by the pooled model are included in the 30 incidents detected by the peak and off-peak models. This small improvement, using a single data set, is not large enough to justify implementing separate models for peak and off-peak periods.

Table 2.11 Model Estimation for Peak and Off-peak Periods

Pooled Model				Peak Model				Off-peak Model			
SOCCDEV	1.278			SOCCDEV	0.994			SOCCDEV	1.356		
SVOLDEV	-0.724			SVOLDEV	-0.690			SVOLDEV	-0.579		
CONSTANT	-7.729			CONSTANT	-5.426			CONSTANT	-13.005		
Threshold	False Alarms (Rate,%)	Detected Incidents (Rate,%)	Detected Incident Periods	Threshold	False Alarms (Rate,%)	Detected Incidents (Rate,%)	Detected Incident Periods	Threshold	False Alarms (Rate,%)	Detected Incidents (Rate,%)	Detected Incident Periods
1.2	0 (0)	29 (20.6)	86	1.9	0 (0)	11 (27.5)	55	-4.5	0 (0)	19 (18.8)	32
0.5	6 (0.0021)	32 (22.7)	93	1.0	5 (0.011)	14 (35.0)	65	-5.0	13 (0.0055)	20 (19.8)	33
0	30 (0.0105)	33 (23.4)	99	0	39 (0.082)	14 (35.0)	73	-5.5	39 (0.0164)	21 (20.8)	36
-0.5	76 (0.0267)	35 (24.8)	105	-1.0	78 (0.164)	15 (37.5)	97	-6.0	63 (0.0266)	22 (21.8)	38
-1.0	106 (0.0372)	36 (25.5)	110	-1.5	107 (0.225)	15 (37.5)	108	-6.5	102 (0.0430)	22 (21.8)	41
-1.5	151 (0.0530)	36 (25.5)	120	-2.0	189 (0.398)	19 (47.5)	128	-7.0	149 (0.0628)	23 (22.8)	45

2.4.4 Model Estimation for Major Incidents Only

As shown in Section 2.2.1, nearly half of all incidents (70 of 141) are minor incidents (traffic stops, motorist assistance, traffic arrests, and suspended driver license.). These incidents are expected to have little or no impact on traffic flow and are difficult to detect. To detect these incidents, the algorithm tends to lower its criteria for incident alarms and therefore generates more false alarms. This section explores the effect of excluding minor incidents in the discriminant analysis on the algorithm performance. The discriminant coefficients and the

algorithm performance for the all incident and major incident only models are reported in Table 2.12.

Table 2.12 Model Estimation for Major Incidents Only

All-incident Model						Major-incident Model					
SOCCDEV		1.278				SOCCDEV		1.367			
SVOLDEV		-0.724				SVOLDEV		-0.822			
CONSTANT		-7.729				CONSTANT		-6.237			
Threshold	False Alarms	False Alarm Rate (%)	Detected Incidents	Detection Rate (%)	Detected Incident Periods	Threshold	False Alarms	False Alarm Rate (%)	Detected Incidents	Detection Rate (%)	Detected Incident Periods
1.2	0	0	29	20.6	86	3.4	0	0	18	25.4	58
0.5	6	0.0021	32	22.7	93	2.25	5	0.0018	18	25.4	60
0	30	0.0105	33	23.4	99	2.0	43	0.0151	20	28.2	67
-0.5	76	0.0267	35	24.8	105	1.5	80	0.0281	22	31.0	72
-1	106	0.0372	36	25.5	110	1.0	108	0.0379	22	31.0	76
-1.5	151	0.0530	36	25.5	120	0.5	150	0.0527	22	31.0	81

Although the detection rate in the major-incident model is higher than in the all-incident model for a similar false alarm rate, the major-incident model detects many fewer incidents, 18 incidents detected in the major-incident model vs. 29 incidents detected in the all-incident model, when no false alarms are generated. Further, the 18 incidents detected in the major-incident model are all included in the 29 incidents detected in the all-incident model. Therefore, the approach of excluding minor incidents does not improve the model performance.

2.4.5 **Summary**

Recalibration of the *ADVANCE* fixed detector arterial algorithm results in substantially improved incident detection when new standardized variables are considered. These models detect 29 of 141 total incidents including 18 of 71 important incidents without generating any false alarms. This result is substantially better than that for the original model. Other approaches, including segmentation of the model by time of day and by incident severity, did not substantially improve the ability of the algorithm to discriminate between incident and non-incident.

Based on these results, the model with standardized occupancy and volume deviation, SOCCDEV and SVOLDEV, is preferred. We employ a conservative threshold which will result in relatively few false alarms[20] and acknowledge that only those impacts which have severe traffic impacts are likely to be detected. This threshold is incorporated in the algorithm (which is programmed to use a threshold of 0.0) by decreasing the constant from -7.729 to -8.929. The resulting equation for the discriminant score is

FD_DISC_FUNC=-8.929+1.278*SOCCDEV-0.724*SVOLDEV.

2.5 Implementation of the Revised Algorithm

The fixed detector algorithm consists of a module which processes current and historic volume and occupancy data from fixed detectors. The historic volume and occupancy data by day type and time of the day, aggregated over a specified time interval for each detector, **is**

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[20] This model obtains no false alarms with the estimation data but would be likely to generate some false alarms if applied to different data.

stored in the 'Historic-Link-Data'. The current volume and occupancy data will be available from the 'TIC-Active-Data'. This data will be screened in TIC for "reasonableness"[21] to determine if it can be used in the fixed detector algorithm. The parameters for the fixed detector algorithm will be stored in the 'TRF_Data' (Berka et al, 1995). The fixed detector algorithm collects the current and historic volume and occupancy data and computes standardized deviations from historic values. It then computes the discriminant score based on these deviations using the parameters reported in Section 2.4.5. The discriminant score will be used to determine incident presence in the proximity of each detector station and identify the roadway links which are affected if a particular detector signals an incident. Incident identifications will be provided to the data fusion module. The fixed detection algorithm will review each detector location during every time period.

The algorithm is identical to that reported in Section 5.2 of TRF-ID-300 and TRF-ID-400 except for changes in variables and parameters in Steps 2.3 and 2.4, exclusion of the heuristic screening rules and elimination of the occupancy only algorithm. Figure 2.6 shows the flow diagram for the fixed detector algorithm. The various steps in the algorithm are:

1.   Determine if the data required can be used in the fixed detector algorithm.

    1.1   If Otag = 1 and Vtag= 1 (indicating that both occupancy and volume data are available) *then go* to step 2, else go to step 5.

2.   Use model with occupancy and volume variables:

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21 The validity of the detector data is tested for: 1) reasonableness of the occupancy data, 2) reasonableness of the volume data, and 3) consistency of volume and occupancy data. Each test consists of one criterion. Criteria for the first two tests are based on fundamental traffic engineering relationships. The third test is based on the statistical relationship between the two measures.

2.1 Obtain current occupancy and volume for the detector station.

    2.1.1 Obtain individual detector occupancy and volume for all the detectors at the station.

    2.1.2 Compute average occupancy (O_s) and total volume (V_s) for detectors at the same station.

2.2 Obtain the historic average occupancy ($O_{\bar{s}}$), average total volume ($V_{\bar{s}}$) and historic standard deviation of occupancy ($O_{\bar{s}d}$) and volume ($V_{\bar{s}d}$) of the detector station for that time period and day type.

2.3 Compute the following variables:

    a) Standardized occupancy deviation: $\text{SOCCDEV} = (O_s - O_{\bar{s}})/\max(O_{\bar{s}d}, 0.5)$.

    b) Standardized volume deviation: $\text{SVOLDEV} = (V_s - V_{\bar{s}})/\max(V_{\bar{s}d}, 3)$.

2.4 Compute the discriminant function FD_DISC_FUNC, for the detector s for the time period t as follows:

$$\text{FD\_DISC\_FUNC} = \beta_0 + \beta_1 * \text{SOCCDEV} + \beta_2 * \text{SVOLDEV},$$

where the β_i are:

    $\beta_0 = -8.929,$

    $\beta_1 = 1.278,$

    $\beta_2 = -0.724.$

3. If FD_DISC_FUNC > 0, an incident is flagged for the detector for that time period, else the conditions are "normal".

4. Store the discriminant score, classification results and relevant explanatory variables, in a temporary file.

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5. Repeat cycle for all detectors.

6. When all detectors are checked, pass the temporary file created in step 4 to ID data fusion module.

```
┌─────────────────────────────────────────┐
│   For all Detector Stations, for Time Period, t │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│   Read Current Volume, Occupancy and        │
│        Data Screening Tags                   │
└─────────────────────────────────────────┘
                    │
                    ▼
              ◇ Are
           Occupancy and         No
           Volume Data      ──────────────►  ( Go to Next Detector Station )
           Reasonable*? ◇
                    │
                    │ Yes
                    ▼
┌─────────────────────────────────────────┐
│   Compute Discriminant Score and            │
│   Classify as "Incident" or  "Normal"        │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│   Save Classification Result, Discriminant  │
│   Score and Variables in FDA Output File     │
└─────────────────────────────────────────┘
                    │
                    ▼
              ◇ Are all
           Detector Station     Yes      ┌──────────────────┐
           Checked? ◇     ──────────────►│ Send FDA Output  │
                    │                     │ File to ID Data   │
                    │                     │ Fusion Module     │
                    │ No                  └──────────────────┘
                    ▼
      ( Go to Next Detector Station )
```

* Data Fusion Algorithm assigns data screening tags to indicate reasonableness of occupancy and volume data (Berka *et al.,* 1995).
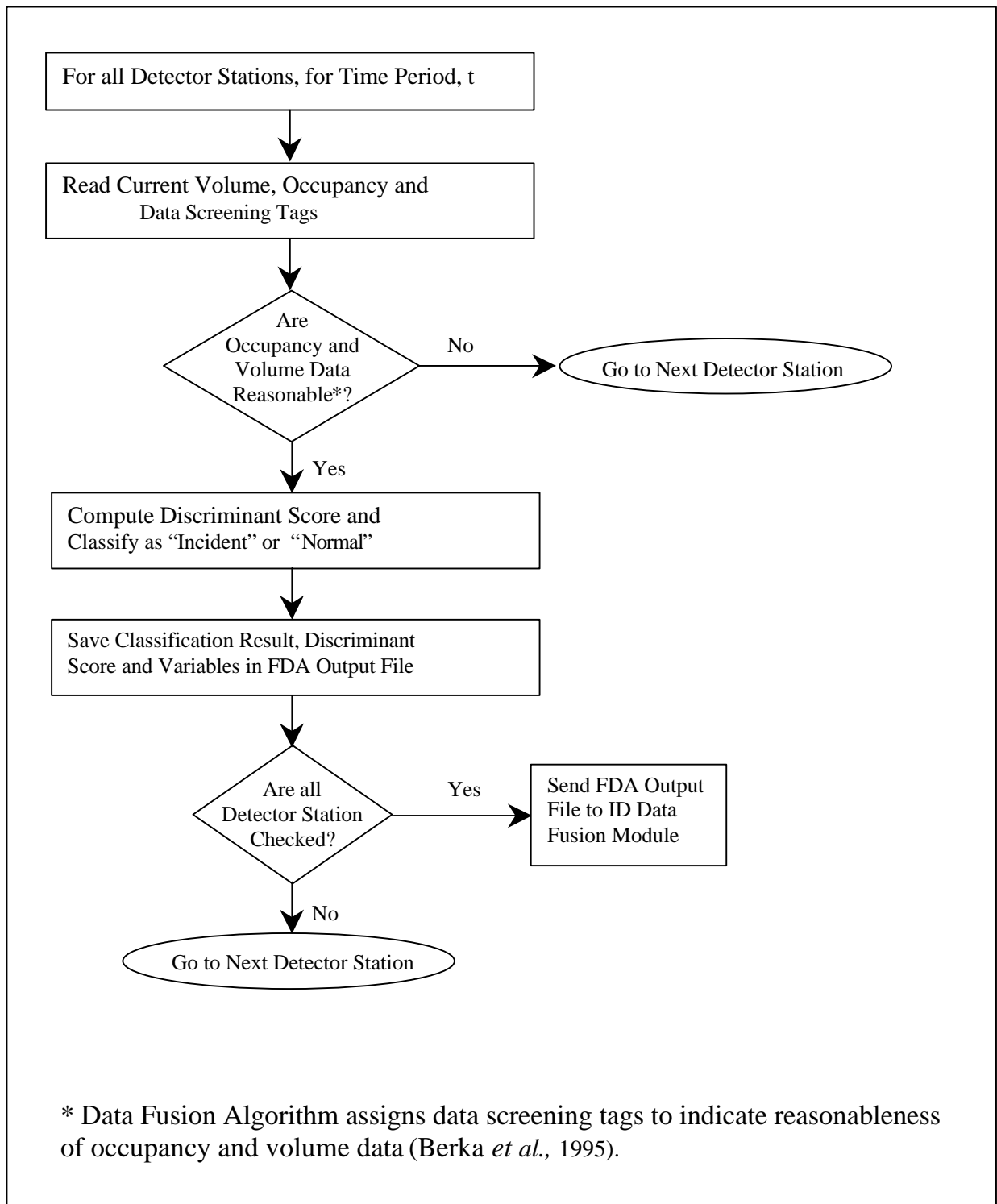
Figure 2.6: Flow Diagram for the Arterial Fixed Detector Algorithm

2.6 Summary of Arterial Fiied Detector Evaluation

The arterial fixed detector algorithm implemented in *ADVANCE* was evaluated for a period of two months at twenty-two locations along Dundee Road using detectors placed at approximately 90 meters upstream from major intersections which are located as much as 600 meters apart,   Of 141 incidents reported during this period, the algorithm detected only seven incidents (and 32 incident periods) while also reporting nine false alarms. The mean time to detect was approximately five minutes after the first report received by local emergency services through Northwest Central Dispatch.   These results were not improved through consideration of screening rules, evaluation by time of day, and incident type.

Consideration of alternative algorithms identified a change in specification, standardization of volume deviation and occupancy deviation by the variability of those measures at each station by time of day, which substantially improved the effectiveness of the arterial fixed detector algorithm.   The revised algorithm was able to identify 29 of 141 incidents (and 86 incident periods) with no false alarms.   The effectiveness of this revised algorithm was substantially better for major incidents (incidents not related to law enforcement); 18 of 71 (25%) major incidents detected vs. 11 of 70 (16%) of law enforcement incidents**. Of the incidents detected, close to half were detected before any report was received by local emergency services.   These results indicate substantial potential for the development of arterial incident detection algorithms based on volume and occupancy data from fixed detectors. Stronger conclusions about the effectiveness of this algorithm require validation with a different

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[22] Detection of law enforcement incidents is of limited value since this information is available in a timely and reliable fashion through communication with local law enforcement agencies.

data set.

Field implementation of an arterial fixed detector algorithm should adopt conservative thresholds to ensure that the number of false alarms in application continues to be zero or very small. Ongoing data collection can be used to update the algorithm to account for both seasonal and long term changes in travel patterns.

3. PROBE VEHICLE ALGORITHM

3.1   Overview

The presence of an incident on a link is expected to increase travel time, reduce speed, of vehicles traversing that link as described in Section 2.1.1.   Probe vehicles collect three data items describing each link traversal; these are travel time (number of seconds from the first second on the link to the first second on the next link), congestion distance (number of meters which the vehicle traveled at less than 10 meters per second) and congestion time (number of seconds during which the vehicle traveled at less than 2 meters per second) (De Leuw *et al.,* 1995).

The *ADVANCE* probe vehicle incident detection algorithm is based on link travel time and average link speed.   Travel time and speed, measured during the current period, are compared to historic averages by taking differences or ratios. The probe vehicle algorithm (PVA) operates in two stages for each five minute period.   The first stage computes the average travel times on links for which reports are available at the end of the time period.   Aggregation of probe reports results in a more accurate representation of travel time conditions by reducing the potential to obtain a false alarm due to a single aberrant non-incident probe report.   The second stage of the PVA applies the algorithm to classify conditions on links for which current data is available as "incident" or "normal".

Variables based on current travel time and its relationship to historic travel time were formulated and estimated based on simulated probe vehicle data. The measures considered included:

(1) Travel Time Ratio: $\text{TTRATIO}[i, t] = \text{TTOBS}[i,t] / \text{TTMEAN}[i,t]$

(2) Speed Ratio: $\text{SPDRAT}[i, t] = \text{TTMEAN}[i,t] / \text{TTOBS}[i,t];$

(3) Travel Time Deviation: $\text{TTNDEV}[i,t] = (\text{TTOBS}[i,t] - \text{TTMEAN}[i,t]) / \text{TTSD}[i,t];$

(4) Speed Deviation: $\text{SPDDEV}[i,t] = ((\text{Link\_Length}/5280)/(\text{TTOBS}[i,t]/3600))$
$-((\text{Link\_Length}/5280)/(\text{TTMEAN}[i,t]/3600));$

where,

TTOBS[i,t]:   observed average travel time on link i for time period t (in seconds),

TTMEAN[i,t]:   historic travel time on link i for time period t (in seconds), and

TTSD[i,t]:   standard deviation of historic travel time on link i for time period t (in
seconds).

A discriminant function, PV_DISC_FN[i,t], for the subject link i and time period t, is computed by

$$\text{PV\_DISC\_FN}[i, t] = \beta_0 + \beta_1 * \text{TTRATIO}[i,t] + \beta_2 * \text{SPDRAT}[i,t] + \beta_3 * \text{TTNDEV}[i,t]$$
$$+ \beta_4 * \text{SPDDEV}[i,t],$$

where the β coefficients depend on the number of reports used to compute the average travel time. The estimated parameter? for different models and the effective cut-off-points[24] for travel time ratio used to identify incidents are reported in Table 3.1. The parameter values reported in Table 3.1 indicate a high level of interdependence between β_0 and β_2. However, the

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[23] Parameter estimates are based exclusively on simulated data. Re-estimation with field data could not be undertaken due to unavailability of probe vehicles and delay in establishment of real time data linkage to NWCD for incident confirmation.

[24] Since the variables in the final model include time and speed ratio only, the effective cutoff between incident and non-incident conditions can be defined in terms of the travel time ratio.

important result of Table 3.1 is that the travel time ratio which indicates an incident is reduced in a consistent manner as the number of reports used to estimate the travel time increases. The algorithm for each link and time period is based on the number of vehicles for which data is available on the link during the time period.

Table 3.1 Estimated Parameters for Discriminant Function and Cut-off Points

| Number of reports | Parameter estimates for discriminant function | | | | | Travel time Ratio |
	β_0	β_1	β_2	β_3	B4	
1	-9.5425	2.6628	0.7740	0.0	0.0	**3.50**
2	-7.4920	2.2961	-1.1592	0.0	0.0	**3.45**
3, 4, 5	-8.1870	3.1157	-1.4207	0.0	0.0	**2.80**
6, 7, 8	-4.7278	2.4847	-4.2547	0.0	0.0	**2.60**
8, ..., 15	-4.4785	2.7365	-4.8784	0.0	0.0	**2.40**
15, 16, ...	26.1091	-1.1258	-35.4857	0.0	0.0	1.45

3.2   Field Data Collection

3.2.1   Procedure for Data Collection

The evaluation of the probe vehicle algorithm requires the collection of NWCD incident reports and probe data during incident and non-incident conditions.

Probe data under incident conditions were collected by assigning a deployed fleet of

vehicles in real time to an incident site within the NWCD jurisdictional area to acquire current link traversal data for the incident and adjacent links. The probe-equipped vehicles traversed the affected area as many times as possible to generate traversal data which was automatically broadcast to the TIC. The vehicles returned to the same site on subsequent days to collect data during non-incident conditions (during successive days when possible).

Planned construction evaluation was designed to make use of scheduled construction as a source of congestion to represent the impacts on traffic flow expected from short term incidents[25]. Initial steps included identification of the locations and scheduled dates for planned construction within the *ADVANCE* test area, and the selection of at least four construction sites to be used for observation, with preference given to sites within the Dundee Rd. corridor. Probe vehicles were driven through construction links in the areas likely to be impacted by the construction. However, the long term nature of the construction projects prevented the collection of post-construction data at all but one site and, in that case, there was a three month gap between the construction and non-construction data collection. For these reasons, the construction evaluation was not undertaken.

25It was recognized that the use of construction as a proxy for an incident was limited due to the extent that driver awareness of the construction would result in route changes which reduce the traffic flow impact of the construction blockage.

3.2.2 Data Description

Data cover a total of twenty weekdays during August and November, 1995, from approximately 2 p.m. to 6 p.m.   Incident data summary forms were used to record the NWCD log number, vehicles assigned and date and time of incident observed.   Probe data included link travel time, congestion distance and congestion time for each traversal.   Historic values for these variables were appended to each link traversal record.

3.3   Evaluation Results

3.3.1 Overview

The arterial probe vehicle incident detection algorithm is evaluated in terms of the number of incidents detected, the number of false alarms and the mean time to detect. The evaluation is undertaken separately for algorithms based on a single report and for sequences of three probe reports.   A single report algorithm may be required in initial implementation of a probe vehicle algorithm as it is very unlikely to obtain two or more reports on a link during an incident period with low levels of fleet penetration.   However, a single report algorithm has the potential for creating a large number of false alarms as it can be triggered when a single vehicle reports an unusually large travel time, possibly for a non-incident related reason. The three report algorithm is expected to provide more reliable incident detection because the effect of an extreme report will be offset by the more representative values of the other reports.   In this evaluation, each sequence of three probe reports on a link is considered as an observation even if the time interval covered exceeds the nominal detection period to provide an indication of the potential effectiveness of a multiple report probe vehicle algorithm.

An incident is counted as detected if it is detected by the applicable algorithm at any time during the incident on the incident link (in either direction) or on one of the adjacent upstream or downstream links. A false alarm occurs if an incident is reported during any non-incident period on any of the links observed.

Examination of the probe data reports identified two data problems which required correction. The problems and the corrections applied to them are:

- The historic travel times for some traversals were unreasonable[26] and differed substantially from the average value for the observed non-incident traversals, which they were expected to represent. In these cases, the historic travel time was replaced by the average travel time for non-incident traversals.

- The probe report system is based on one-second monitoring of the vehicle location. A link traversal is considered to begin at the first one-second observation of a new link and to end at the first one-second observation on another link. However, some *ADVANCE* links, such as turning lanes or ramps, are so short that no one-second observation occurs on them for some traversals. Travel times on these "short links" are likely to be unavailable. In such cases, the "short link resolver" (De Leuw *et* al., 1995) allocates the travel time between the short link and the adjacent upstream link. We found the resulting values for travel time, congestion distance and congestion time to be unreliable. To retain useful traversal information to the maximum extent possible, the traversal data for

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26 In some cases, the historic travel time implied a value of average link speed well outside the likely range of link speeds. The historic travel times were obtained from a network traffic flow model (Boyce *et al.,* 1994). In some cases, where the link was traversed many times the historic travel times were updated as part of the TRF Static Profile algorithm (Thakuriah *et al,* 1994).

the pair of links was re-combined in these analyses.

3.3.2 Initial Evaluation Results

Detailed evaluation results for each of twenty incidents for which incident and non-incident data were available are reported in Appendix A which includes information describing the incident, probe traversal assignments, incident indicator scores for single and sets of three probe traversals and the interpretation of each probe traversal during both incident (incident detection or not) and non-incident (false alarm or not) conditions. A summary of this information for seventeen incidents[27] is reported in Tables 3.2a for severe incidents (accident with property damage and accident with personal injuries) and 3.2b for non-severe incidents (light malfunction, stalled truck/train and motorist assistance) where each incident is characterized by incident type and duration. The tables report the number of detections obtained by the algorithm relative to the number of traversals for the incident link and the adjacent upstream and downstream links during both incident and non-incident conditions for two directions of traffic flow**. The results for each incident include one row where identification is based on single traversals and one row for three sequential traversals. For example, the first incident entries for Incident 1 indicate that six of nineteen traversals on the incident link in Direction 1 indicate the presence of an incident. Similarly, the next row indicates that seven of

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[27] Four of the initially identified incidents were excluded because they occurred on links which were under construction during the incident day.

[28] The directions are arbitrarily designated as the direction of the incident lanes is not included in the incident descriptions.

fifteen sets of three traversals indicated the presence of an incident[29].

These results are further summarized in Table 3.3 which indicates the number of severe incidents, non-severe incidents and all incidents detected. These results indicate a good level.

Table 3.2a Evaluation Results of Probe Vehicle Incident Detection Model

Incidents Number and Type[30]	Duration	Number of Reports	Incident Detections						False Alarms					
			Incident Links		Up-stream Links		On-stream Links		Incident Links		Up-stream Links		On-stream Links	
			Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2
1. ACPD	72	1	6/19	0/14	0/8	N/A			0/58	0/43	0/22	N/A		
		3	7/15	0/8	0/6	N/A			0/54	0/39	0/20	N/A		
2. ACPD/I	53	1	0/3	0/1	N/A	N/A			0/20	0/5	N/A	N/A		
		3	0/1	N/A	N/A	N/A			0/18	0/3	N/A	N/A		
4. ACPI	93	1	1/2	0/2	0/1	N/A	0/3		0/36	0/15	0/42	N/A	2/38	
		3	N/A	N/A	N/A	N/A	0/1		0/34	0/13	0/40	N/A	0/36	
7. ACPD	39	1	0/4	N/A	0/2	N/A			0/23	N/A	0/41	N/A		
		3	0/2	N/A	N/A	N/A			0/21	N/A	0/39	N/A		
8. ACPI	51	1	N/A	N/A	0/2	0/1			N/A	N/A	0/6	0/6		
		3	N/A	N/A	N/A	N/A			N/A	N/A	0/4	0/4		
9. ACPD	61	1	1/3	0/1	0/1	N/A			0/4	0/2	0/3	N/A		
		3	N/A	N/A	N/A	N/A			0/1	N/A	0/1	N/A		
13. ACPI	79	1	4/6	0/2	N/A	N/A			0/61	0/25	N/A	N/A		
		3	N/A	N/A	N/A	N/A			0/55	0/23	N/A	N/A		
14. ACPD	78	1	N/A	N/A	0/5	1/5			N/A	0/3	0/15	N/A		
		3	N/A	N/A	0/3	0/3			N/A	0/1	0/13	N/A		
17. ACPI	59	1	1/3	N/A	N/A	N/A			0/18	N/A	N/A	N/A		
		3	1/1	N/A	N/A	N/A			0/16	N/A	N/A	N/A		
2O. ACPD	84	1	0/2	N/A	0/2	N/A	2/2		1/61	N/A	0/69	N/A	1/60	
		3	N/A	N/A	N/A	N/A	N/A		0/59	N/A	0/67	N/A	0/58	

---

[29] The number of sets of three sequential reports is equal to the number of single reports reduced by two for each turning movement.

[30] Incident types include accident with property damage (ACPD), accident with personal injuries (ACPI), light malfunction (LMAL), stalled train and truck, repair truck and motorist assistance.

Table 3.2b Evaluation Results of Probe Vehicle Incident Detection Model

Incidents Number and Types	Duration	Number of Reports	Incident Detections						False Alarms					
			Incident Links		Up-stream Links		Dn-stream Links		Incident Links		Up-stream Links		Dn-stream Links	
			Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2	Dir.1	Dir.2
5 Stalled Train	15	1	2/8	0/6	0/1	0/2			0/37	0/16	0/14	0/5		
		3	1/4	0/4	N/A	N/A			0/33	0/14	0/12	0/3		
6. Repair Truck	70	1	0/5	0/6	0/4	0/7			0/17	0/35	0/16	0/35		
		3	0/3	0/4	0/2	0/5			0/15	0/33	0/14	0/33		
10.LMAL	66	1	1/5	1/5	2/5	N/A	0/3		0/7	0/7	0/7	N/A	0/7	
		3	3/3	0/3	2/3	N/A	0/1		0/5	0/5	0/5	N/A	0/5	
12.LMAL	28	1	0/3	2/3	N/A	N/A	0/2		0/32	0/46	N/A	N/A	0/42	
		3	1/1	1/1	N/A	N/A	N/A		0/30	0/44	N/A	N/A	0/40	
18 Stalled Truck	30		2/8	N/A	2/8	N/A	0/2		1/9	N/A	0/16	N/A	0/15	
		3	2/6	N/A	1/6	N/A	N/A		0/7	N/A	0/14	N/A	0/13	
19 Motorist Assistance	25	1	2/2	0/1	0/3	0/1			0/63	0/64	0/89	0/70		
		3	N/A	N/A	0/1	N/A			0/61	0/62	0/87	0/68		
21 .LMAL	105	1	3/3	0/7	N/A	N/A	0/7		0/54	2/34	N/A	N/A	0/15	
		3	1/1	0/5	N/A	N/A	0/5		0/52	0/32	N/A	N/A	0/13	

Table 3.3 The Initial Evaluation of Probe Vehicle Incident Detection Algorithm

Performance	Single Report[31]			Three Reports[32]		
	Severe	Non-severe	Total	Severe	Non-severe	Total
# of Incidents	8	7	15	4	7	11
# of Incidents Detected	6	5	11	2	4	6
# of Incident Traversals	94	107	201	40	58	98
# of Incident Traversals Detected	16	17	33	8	12	20
# of False Alarms	-33	--	7	--	--	0
DR (%)	75.0	71.4	73.3	50.0	57.1	54.5
FA (%)	0.7	0.4	0.5	0.0	0.0	0.0

of incident detection for the algorithm based on single reports but with an unacceptably high false alarm rate. The corresponding data for the algorithm based on three sequential reports obtains a lower but still good detection rate with no false alarms. These results confirm that an algorithm based on single probe reports is likely to produce an unacceptably large number of

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[31] Incidents #8 and 14 were excluded from this table because no data was obtained on the incident links.

[32] Four of eight severe incidents (4, 9, 13 and 20), which included fewer than three probe reports on the incident link, are excluded in assessment of the three report algorithm.

[33] False alarms are not disaggregated according to severity of the associated incidents as the condition during the false alarm period is unrelated to the incident other than by time of day and location.

false alarm?. The results also indicate that while the primary detection of incidents occurs on the incident links, there **is** some potential to identify an incident on an adjacent upstream **or** downstream link. Finally, the algorithm appears to perform approximately as well for the types of incidents we classify as severe and the types we classify as not severe.

3.4 Modifications of Incident Detection Algorithms

Modification of the PVA was undertaken separately for the algorithm based on a single probe report and the algorithm based on three sequential probe reports. The model parameters **for** the single probe report case are estimated using field data for 13 incidents[35] and for the three probe report case using data for 11 incidents as in Table 3.3. The data files include probe reports on incident links and adjacent up- and down-stream links in each direction during both incident and non-incident conditions. In addition to the variables defined in section 3.1, the analysis includes the congestion distance deviation and ratio[36].

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[34] A false alarm rate of 0.5% will result in large numbers of false alarms on even a small network.

[35] All incidents in Table 3.3 were included except for incidents 2 and 7 which are undetectable due to low travel time.

[36] The congestion distance ratio (CDRATIO) is the ratio of current to historic congestion distance. The congestion distance deviation (CDDEV) is the deviation of current to historic congestion distance. The congestion time was excluded from the analysis because it is missing **on** ten percent of the probe reports.

3.4.1 Model Estimations Using Single Reports

The estimation results of the PVA based on single reports are given in Table 3.4 including the discriminant function coefficients and performance measures for incidents detected[37], incident traversals classed as incidents[38] and non-incident traversals classified as incidents (false alarms). The first two models include travel time ratio without and with travel time deviation[39]; the next two models add congestion distance deviation to these models. All four models detect the same number of incidents and produce approximately the same number of false alarms when tested with threshold equal to zero but the models with congestion distance deviation outperform the corresponding models with time variables only with respect to the number of incident traversals detected. The threshold for each of these models can be adjusted such that they do not produce any false alarms in this data set. When the thresholds are so adjusted, the simplest model with travel time ratio alone obtains the best incident results with nine of thirteen incidents and 17 of 76 incident traversals detected[40]. Further, the thresholds for each of these models can be adjusted to an intermediate value with which the model outperforms the probe vehicle algorithm implemented in *ADVANCE* (more incidents and incident periods

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[37] An incident is considered to be detected if one or more incident traversals (or sequences of three traversals in the case of the three report algorithm) are identified as incident traversals.

[38] A greater number of incident traversals identified provides higher assurance that the incident would be identified under condition of fewer probes operating.

[39] Models with travel time ratio with or without travel time deviation are consistently better than corresponding models with speed ratio with or without speed deviation and the addition of the speed related variables to models which include travel time related variables results in little or no improvement in classification so these variables are excluded from further consideration.

[40] Seventy-six traversals on incident, upstream and downstream links on which the traffic flow was impacted are used for model estimation.

detected and fewer false alarms).

Table 3.4 Probe Vehicle Detection Discriminant Parameters and Classification Performance Based on Single Reports

Variables		Model 1		Variables		Model 2	
TTRATIO		1.435		TTRATIO		0.972	
Constant		-4.240		TTDEV		0.008	
				Constant		-3.789	
Threshold	Incidents Detected	Incident Traversals Detected	# of False Alarms	Threshold	Incidents Detected	Incidcnt Traversals Detected	# of False Alarms
2.600	9	17	0	4.258	6	10	0
2.444	10	19	1	1.761	12	29	1
2.128	11	23	2	1.437	12	31	2
0	13	43	11	0	13	44	10

Variables		Model 3		Variables		Model 4	
TTRATIO		1.099		TTRATIO		0.903	
CDDEV		0.005		TTDEV		0.004	
Constant		-4.125		CDDEV		0.004	
				Constant		-3.889	
Threshold	Incidents Detected	Incident Traversals Detected	# of False Alarms	Threshold	Incidents Detected	Incident Traversals Detected	# of False Alarms
4.330	7	10	0	5.000	5	8	0
2.062	12	27	1	2.362	12	25	1
1.817	12	29	2	1.805	12	30	2
0	13	50	11	0	13	50	11

The effect on incident detection and false alarms of increasing the threshold can be seen in Figure 3.1 which shows the discriminant boundary and the individual traversal values for Model 3 (travel time ratio and congestion distance deviation) for the threshold set at zero and at 4.33 (no false alarms). Adjustment of the threshold is represented by "upward to the right" movement of the line without changing its slope. Traversals with data above the boundary for each threshold are classified as incidents for that threshold. The true incident characteristics are indicated by the symbols in the figure. Pluses are non-incident data and triangles represent incident traversals. The dark triangles represent the traversal with the highest score for each incident. It is apparent that, for Model 3 with threshold equal to zero, all the incidents are detected (13 dark triangle above the boundary) as well as a number of other incident traversals but with eleven false alarms. Using this algorithm, the number of false alarms can be reduced by increasing the threshold. As shown, increasing the threshold to 4.33 will eliminate all the false alarms but also eliminates a number of incident detections (dark triangles) and a number of secondary detections (open triangles). Recognizing that more extensive link coverage would result in many more non-incident traversals and many more false alarms, it would be appropriate to set the threshold at a value equal to or greater than the value which eliminates all false alarms in this data set (to reduce the possibility that additional false alarms will be generated in a general implementation). This figure can also be used to compare Model 3 with Model 1 represented by the horizontal dashed line. While Model 1 with zero false alarms identifies two additional incidents, its boundary is very close to a number of non-incident traversals which suggests a relatively high potential for false alarms in a larger data set. This suggests that it might be more appropriate to adopt Model 3 which has a slightly lower detection effectiveness

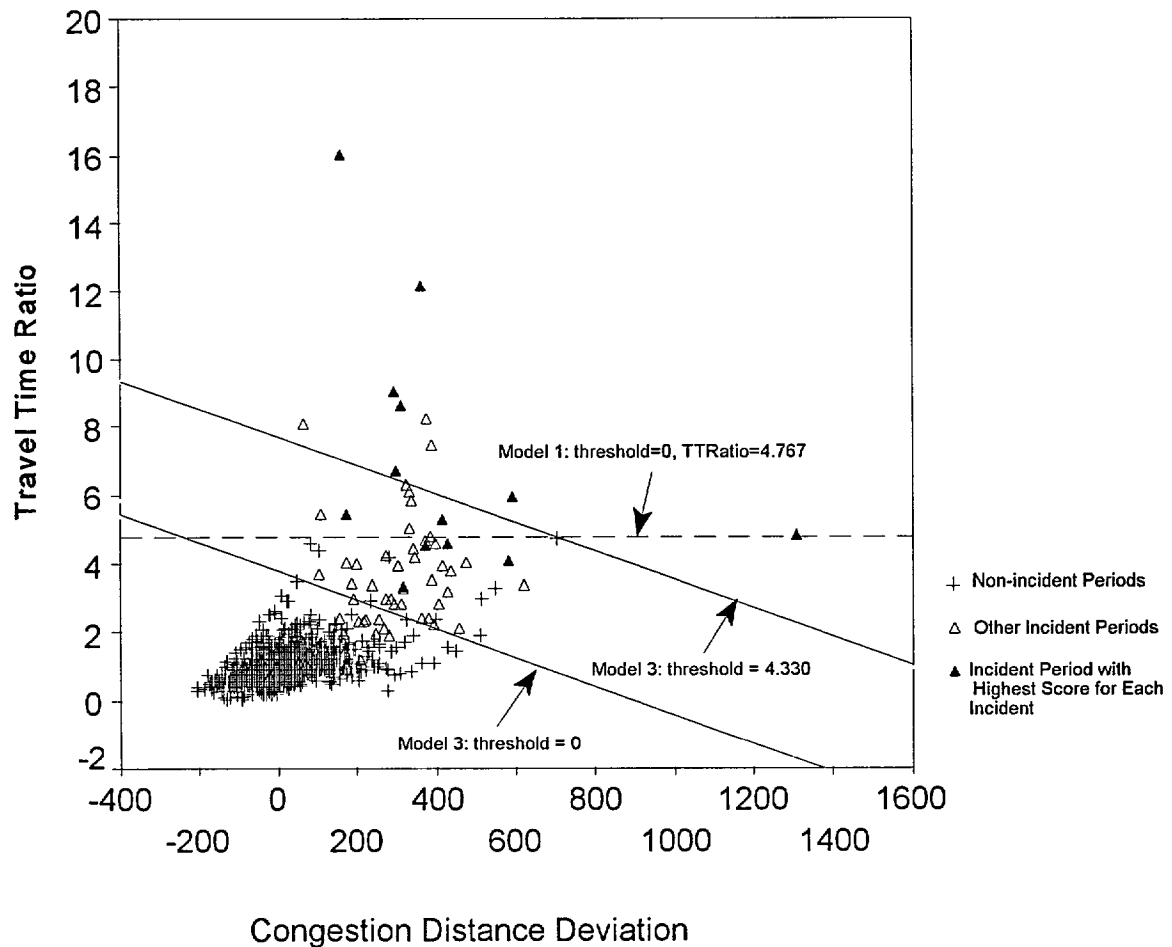but also has a smaller potential for the generation of false alarms[41].

Figure 3.1: Effect of the Thresholds on the Single Report Model Results

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[41] A small number of false alarms in this small data set would suggest the potential for a huge number of false alarms for a representative data set including traversals on numerous links every day.

3.4.2 Model Estimations Using Three Reports

The estimation results of the PVA based on three probe reports using the same specifications as for the single probe report case are given in Table 3.5. All four models have identical incident classification results when compared with thresholds adjusted to eliminate all false alarms; they detect all of the incidents considered and 24 of 34 sequences of three probe reports selected for analysis[42]. These models perform better than the corresponding single probe report models as they detect all incidents but with fewer false alarms.

The advantages of Model 3 over Model 1 can be seen in Figure 3.2 which includes the threshold boundary which eliminates all false alarms in both cases. Using the threshold for Model 3 (solid line), one non-incident traversal (a potential false alarm) is close to the boundary, while for Model 1 (long dash line) a number of non-incident traversals are close to the boundary. This indicates that adoption of Model 1 would have a much larger potential for the generation of false alarms if it were implemented in a full scale deployment. These models can be compared to the model implemented in *ADVANCE* with Travel Time Ratio equal to 2.80 (short dashed line) which avoids false alarms but misses some incidents detected by the other algorithms.

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[42] Thirty-four sets of three traversals on incident, upstream and downstream links on which the traffic flow was impacted are used for model estimation.

occupancy variables). However, it also indicates the limitation of this specification to provide

an effective arterial incident detection algorithm.

Table 2.7 Fixed Detector Detection Discriminant Parameters and Classification Performance

Variables		Model 1		Variables		Model 2	
TTRATIO		3.165		TTRATIO		2.721	
Constant		-7.198		TTDEV		0.007	
				Constant		-6.687	
Threshold	Incidents Detected	Incident Periods Detected	#of False Alarms	Threshold	Incidents Detected	Incident Periods Detected	#of False Alarms
0	9	24	0	0.001	9	24	0
-0.281	9	24	1	0	9	24	1
-0.406	9	24	2	-0.307	9	24	2

Variables		Model 3		Variables		Model 4	
TTRATIO		2.506		TTRATIO		2.368	
CDDEV		0.006		TTDEV		0.002	
Constant		-6.625		CDDEX+V		0.006	
				Constant		-6.550	
Threshold	Incidents Detected	Incident Periods Detected	#of False Alarms	Threshold	Incidents Detected	Incident Periods Detected	#of False Alarms
0.524	9	24	0	0.531	9	24	0
0	9	27	1	0	9	27	1
-0.392	9	28	2	-0.483	9	28	2
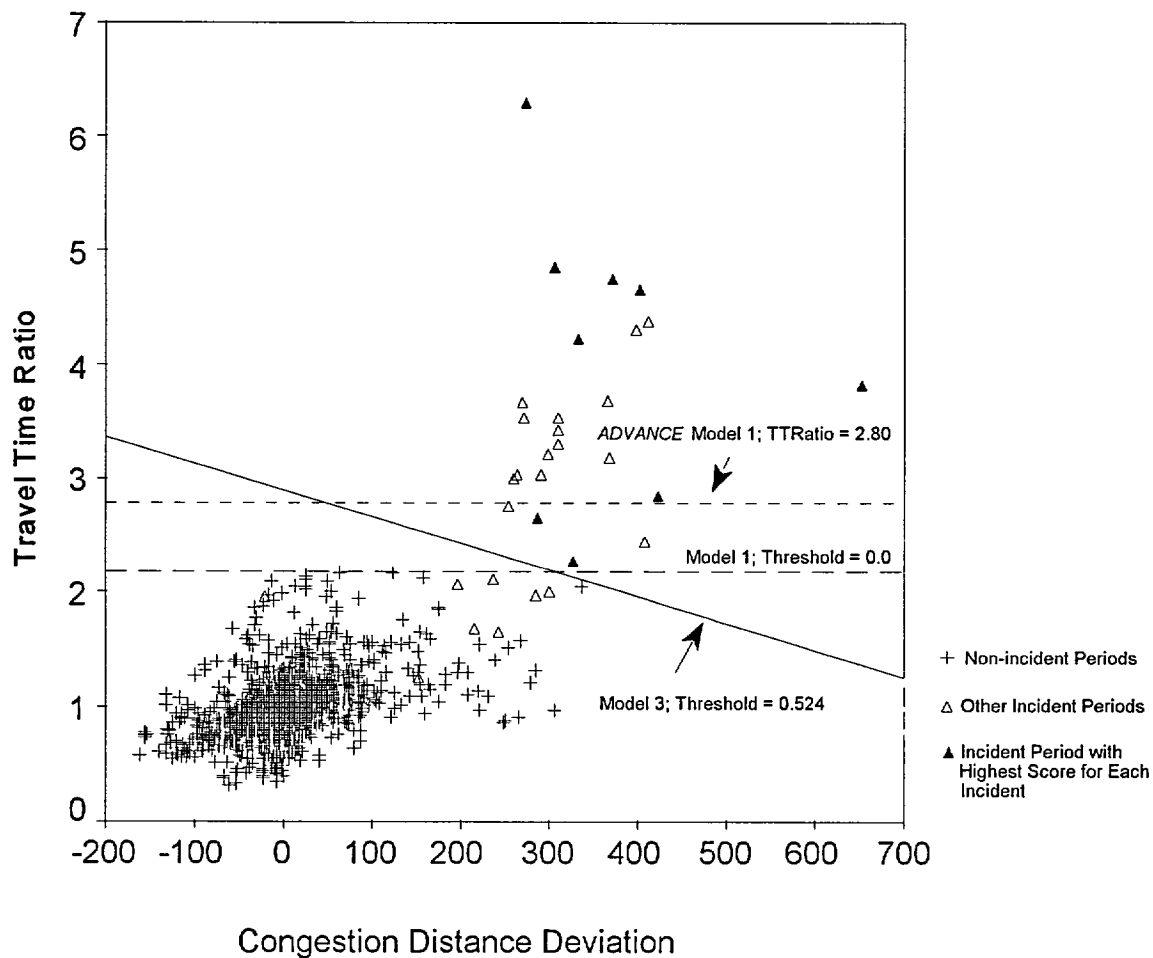
Figure 3.2: Effect of the Thresholds on the Three Report Model Results

The figure shows a scatter plot with axes:
- Y-axis: Travel Time Ratio (0 to 7)
- X-axis: Congestion Distance Deviation (-200 to 700)

Labels in plot:
- ADVANCE Model 1; TTRatio = 2.80
- Model 1; Threshold = 0.0
- Model 3; Threshold = 0.524

Legend:
- + Non-incident Periods
- △ Other Incident Periods
- ▲ Incident Period with Highest Score for Each Incident

3.4.3 Summary

During the early years of ITS deployment, the number of probe-equipped vehicles will be small and the TIC will receive very few reports per time period except for the most heavily travelled links. This paucity of probe data will encourage the use of a single probe report algorithm. While such an algorithm can be implemented, it is likely to detect only a small fraction of incidents if the threshold is set high enough to avoid a large number of false alarms.

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These evaluation results indicate that a detection algorithm based on sequences of three or **more** probe reports will perform substantially better than one based on single reports.

The three report algorithm uses the travel time and congestion distance reported by probes to detect incidents. The model, based on the ratio of current to historic average travel times and the deviation of current to historic average congestion distances, obtained a high detection rate (100%) and a zero false alarm rate in this limited case.

It is essential to select a threshold which will ensure a very low false alarm rate because the field conditions in a large network will result in greater variability of travel times and congestion distances under non-incident conditions than that observed in our field experiment. We adopt a threshold which will result in no false alarms and a relatively small chance of generating false alarms with large field data and recognize that some fraction of incidents which have less severe traffic impacts are not likely to be detected. The resulting equation for the discriminant score is

PV_DISC_FN = -7.149 + 2.506xTTRATIO + 0.006xCDDEV

3.5   Implementation of the Revised Algorithm

The PVA requires current and historic probe vehicle data, and is designed to compute the averaged values of three reports each time. The historic data would be stored in the *ADVANCE* database 'Historic-Link-Data-Profile'. The current data would be provided to the incident detection module by 'TIC-Active-Data'. The parameters for the probe vehicle algorithm will be stored in the ' TRF_Data' .

The PVA operates in two stages. The first stage is the computation of the average travel

times and congestion distances on the links by aggregating three sequential probe reports each time. The second stage of PVA is the application of the algorithm to classify conditions on the links as "incident" or "normal". Figure 3.3 shows the flow diagram for the PVA. The steps in the algorithm are:

1. Obtain the current travel time and congestion distance for the link i at time t, if data is available. If not, go to the next link.

    1.1   Collect the current travel time and congestion distance for link i at time t.

    1.2   Compute the average travel time and congestion distance using current probe reports and probe reports for up to two previous periods if needed to obtain three probe reports.

2. Obtain the historic travel time and congestion distance for link i at time t.

    2.1   Collect the historic travel time and congestion distance for link i at time t.

    2.2   Compute the average historic travel time and congestion distance[43] on link i across all time periods for which probe data is included in step 1.

3. Compute the following variables:

    TIRATIO[i,t]   = TTOBS[i,t] / TTMEAN[i,t];

    CDDEV[i,t]   = (CDOBS[i,t] - CDMEAN[i,t]);

---

[43] The historic travel time and congestion distance associated with each probe report are fixed within time periods. However, in cases where sequential reports cross a major time period boundary (e.g., at 4 pm), the average provides a better representation of expected values.

where,

TTOBS[i,t]: Average three observed travel time on the link i at time t,

TTMEAN[i,t]: Average three historic travel time on the link i at time t,

CDOBS[i,t]: Average three observed congestion distance on the link i at time t, and

CDMEAN[i,t]: Average three historic congestion distance on the link i at time t.

4. Compute the discriminant function, PV_DISC_FN[i,t], for link i at time t as follows:

PV_DISC_FN[i, t] = β_0 + β_1 X TTRATIO[i,t] + β_2 X CDDEV[i,t]

where β_is are:

β_0 = -7.149,

β_1 = 2.506,

β_2 = 0.006.

5. If PV_DISC_FN[i,t] > 0, an incident is flagged for the link i at time t, else the conditions are 'normal'.

6. Store the discriminant score, classification results and relevant explanatory variables, in a temporary file.

7. Repeat cycle for all links.

8. When all links are checked, pass the temporary file created in step 6 to ID data fusion module.
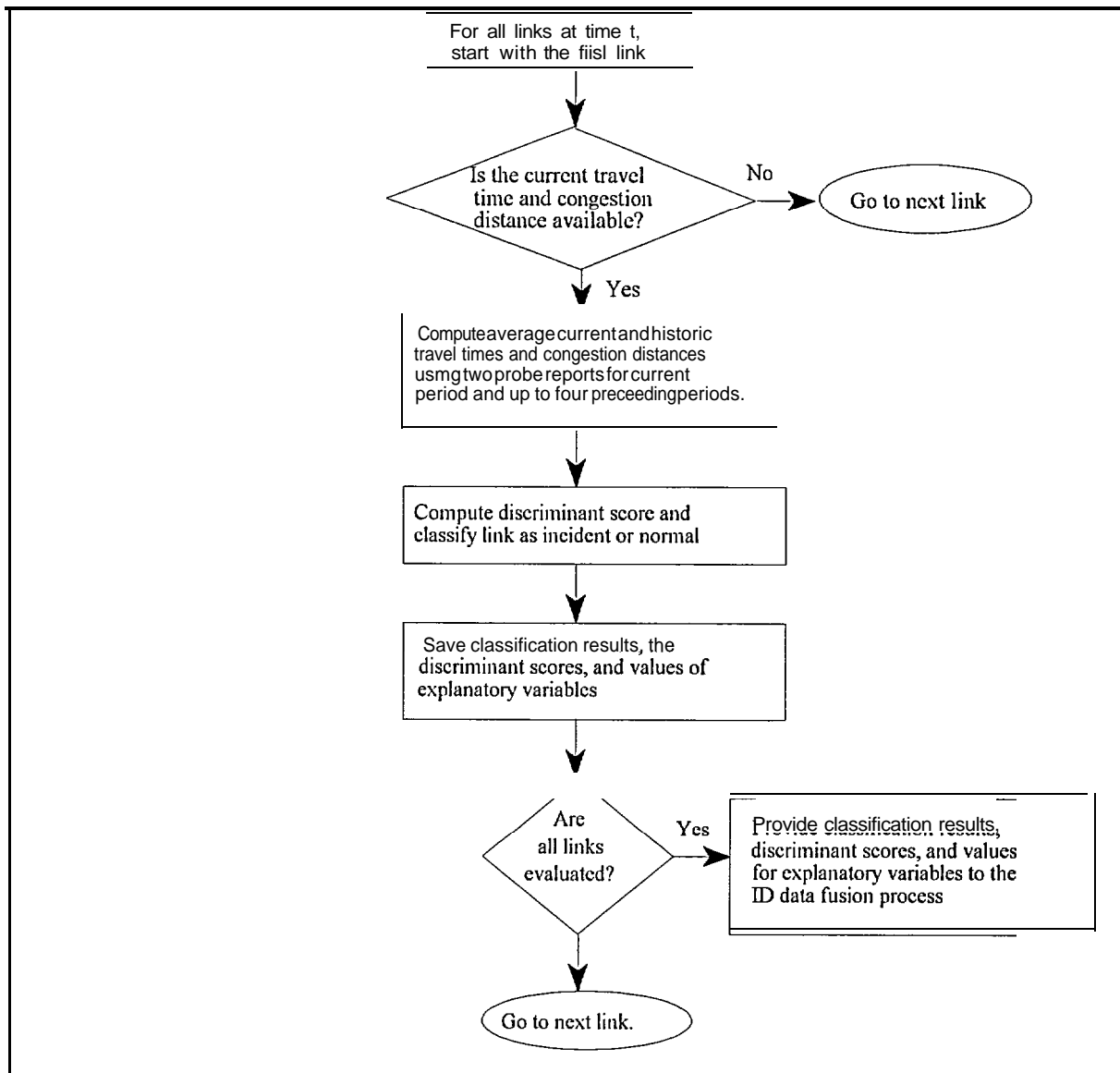
Figure 3.3: Flow Diagram for the Arterial Probe Vehicle Algorithm

3.6 Summary of Arterial Probe Vehicle Evaluation

The arterial probe vehicle algorithm implemented in *ADVANCE* was evaluated for a period of twenty days (ten days in August and ten days in November) within the *ADVANCE area* covered by Northwest Central Dispatch. Evaluation was based on the analysis of individual probe reports and sequences of three probe reports on the incident and adjacent links.

The single report algorithm identified eleven of fifteen incidents for which single reports were available but also produced seven false alarms. The three report algorithm identified six of eleven incidents for which sequences of three reports were available without any false alarms. These results favor the adoption of the three report algorithm over the single report algorithm. However, even the three report algorithm is likely to generate false alarms in a general implementation[44].

Consideration of alternative algorithms identified the potential to improve the three probe algorithm through a change in specification, addition of congestion distance deviation, which improved the effectiveness of the arterial fixed detector algorithm in terms of incident traversals identified and reduced potential of false alarms.

Both the evaluation and modification results support the contention that probe vehicle incident detection be based on the use of multiple reports to reduce the potential for numerous false alarms based on unusual readings from a single vehicle caused by reasons other than disruptions in traffic flow on a link.

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[44] The number of false alarms is directly proportional to the size of the network and the number of days of operation. Given the variability of link travel time data, the result of no false alarms in this data set does not provide strong assurance that the number of false alarms would be small in a larger implementation.

Implementation of the probe vehicle arterial incident detection algorithm can only be expected to be successful if the number of vehicles equipped is large enough to ensure a reasonable likelihood of multiple probe vehicle reports on potential incident links during relatively short time periods during peak travel conditions.   This might reasonably be accomplished if probe vehicles were 3-5 % of the total fleet which would produce an average of 2.5 to 4 probe reports on arterial links for each five minute interval during peak periods.

4. EXPRESSWAY ALGORITHM

4.1 Overview

The Expressway ID Algorithm is based on the California Algorithm[45] which compares the value of variables derived from traffic measurements to pre-selected thresholds in a decision tree within which an incident is declared when the data conform to pre-selected criteria. These variables are:

- the spatial difference between downstream and upstream occupancy, OCCDF, which is calculated from occupancy at the upstream station, i, at time, t, and the occupancy at the downstream station, i+ 1, at the same time; that is $OCCDF_{i,1}= OCC_{i,t}-OCC_{i+1,t}$;

- the relative spatial difference between downstream and upstream occupancy, OCCRDF, which is the spatial difference in occupancy divided by the upstream occupancy; that is $OCCRDF_{i,t}=$

- the relative temporal difference in downstream occupancy, DOCCTD, which is calculated as the difference in downstream occupancy over two time periods relative to the downstream occupancy in the earlier time period; that is $DOCCTD_{1,t}=$ $(OCC_{i+1,t-2} - OCC_{i+1,1})/OCC_{i+1,t-2}$; and

- the downstream occupancy, DOCC, which is equal to $OCC_{i+1,t}$. Since DOCC has two different threshold values for different functions, it is shown as DOCCl and DOCC2 in the algorithm.

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[45] The California Algorithm (Payne *et al,* 1976) was selected by the *ADVANCE* project office.

The decision structure of the expressway incident detection algorithm is illustrated as a binary sequential decision tree (see Figure 4.1). The highest levels of the decision tree routes the algorithm to a series of tests depending on the current state (incident free, state 0; tentative incident, states 2 and 6; confirmed incident, state 7; terminated incident, state 1; or compression wave[46], states 3 to 5) of the expressway based on data in preceding time periods and the downstream occupancy.
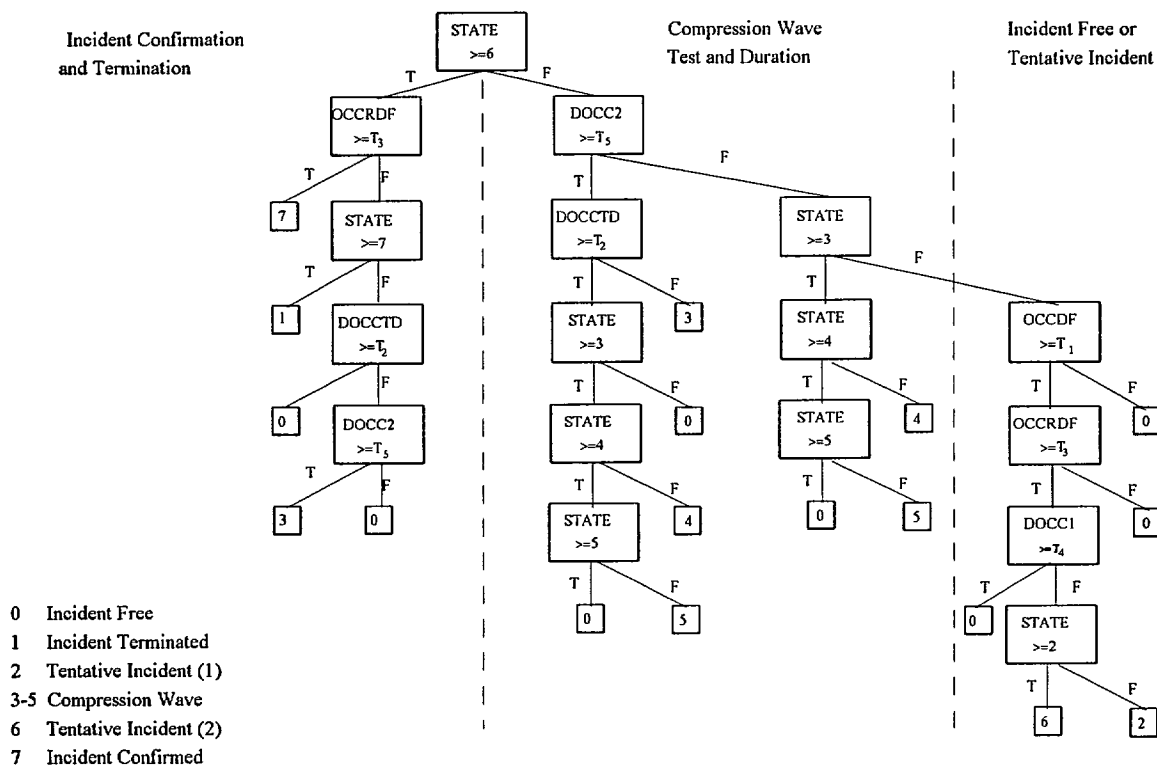
Incident Confirmation and Termination

STATE >=6

Compression Wave Test and Duration

Incident Free or Tentative Incident

OCCRDF >=T_3

DOCC2 >=T_5

7   STATE >=7

DOCCTD >=T_2

STATE >=3

1   DOCCTD >=T_2

STATE >=3   3

STATE >=4

OCCDF >=T_1

0   DOCC2 >=T_5

STATE >=4   0

STATE >=5   4

OCCRDF >=T_3   0

3   0

STATE >=5   4

0   5

DOCC1 >=T_4   0

0   5

0   STATE >=2

6   2

0   Incident Free
1   Incident Terminated
2   Tentative Incident (1)
3-5 Compression Wave
6   Tentative Incident (2)
7   Incident Confirmed

Figure 4.1 Decision Tree of Expressway Incident Detection Algorithm

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[46] A compression or shock wave occurs when a queue forms upstream from an area of high congestion or reduced flow. The compression wave will propagate upstream at a rate depending on the speed and volume of traffic on the roadway. Thus, a compression wave on a road segment is indicated by an increase in occupancy at the downstream detector followed by an increase at the upstream detector.

The threshold values for the five criterion variables are chosen by using a single stage procedure in which the trade-off between increasing detection rate and increasing false alarm rate is selected a priori. The objective in this case can be thought of as trying to obtain a maximum detection rate adjusted by the weighted false alarm rate. An increasing weight implies a greater emphasis on avoiding false alarms. The thresholds for this algorithm were estimated using one minute reports of volume and occupancy and incident presence information for the Edens Expressway[47].These thresholds and the resultant detection and false alarm rates are shown in Table 4.1 for five different false alarm penalty weights.

Table 4.1 Estimation Thresholds and Results

False Alarm Penalty Weight	Threshold Values					Detection Rate (%)	False Alarm Rate (%)
	OCCDF	DOCCTD	OCCRDF	DOCC1	DOCC2		
50	6.8	-0.242	0.238	25.8	23.7	69.0	0.923
100	9.1	-0.685	0.215	18.9	30.2	52.9	0.412
150	11.3	-0.687	0.163	18.1	23.7	49.4	0.281
200	15.9	-0.700	0.155	18.9	23.9	39.1	0.160
300	26.7	-0.959	0.192	18.9	24.8	19.5	0.020

The structure of the decision tree can be understood best by considering its three primary functions: tentative incident identification, incident confirmation and termination and identification of compression waves. The first component tests for the existence of a

[47] The Edens Expressway is a 17mile, six-lane, north-south expressway from the north side of Chicago (8 miles from the CBD) to Deerfield Rd in Highland Park.

compression wave (middle of Figure 4.1).   A compression wave is declared when downstream occupancy is greater than its threshold, 24.8%[48], and downstream occupancy time difference is increasing rapidly, 95.9 % .   Once a compression wave has been declared, the algorithm maintains compression wave status for the next two one-minute periods; that is, the algorithm allows three minutes total for the compression wave to pass through the roadway segment defined by the station pair.

The second function, tentative incident identification (right side of Figure 4. l), is based on the values of the thresholds for spatial occupancy difference, OCCDF, relative spatial occupancy difference, OCCRDF, and downstream occupancy, DOCCl. A tentative incident will be identified when OCCDF is greater than 26.7% and OCCRDF is greater than 19.2% unless downstream occupancy is high enough, l8.9%, to indicate that any occupancy differences are due to downstream congestion.   These criteria must be met for two sequential time periods before incident confirmation is considered.

The first function of the third component (left side of Figure 4. l), incident confirmation, occurs if the relative occupancy difference continues to be greater than its threshold for one additional period. If the incident is not confirmed, the algorithm either identifies a compression wave (under the same conditions described earlier for compression wave identification) or resets the state to the incident free condition.   The second function of the third component terminates a confirmed incident when the relative occupancy difference, OCCRDF, drops below its threshold; that is, as soon as the difference between upstream and downstream occupancy drops

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[48] Example values based on the most conservative model (a=300) which emphasizes reduction in false alarms.

below 19.2% of the downstream occupancy.

The incident detection performance of the expressway algorithm was judged to be unsatisfactory due to the large number of expected false alarms compared to the expected number of successful incident detections. Despite this, the evaluation is undertaken to examine the transferability of the algorithm to a different context.

4.2 Evaluation Data

The computation of the Expressway Incident Detection Algorithm is based on one-minute reports for each station pair on the expressway considered. Each report includes the four variables defined in Section 4.1 from the fixed detector files and an incident indicator based on data from *999 and the Emergency Traffic Patrol. The evaluation data set includes data for the Kennedy Expressway[49] from O'Hare Airport to the Eisenhower Expressway, inbound, for peak periods[50] during the month of May. The incident data includes 87 non-disabled-vehicle incidents during peak periods. The non-incident data has been screened to include 35 hours of incident free peak period data for each station pair, compared to 184 hours of observed weekday peak period data.

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[49] The Kennedy Expressway is a 16-mile, eight lane, expressway from downtown Chicago to O'Hare Airport.

[50] Peak periods are defined as 6:00 am to 10:00 am and 3:00 pm to 7:00 pm during weekdays.

4.3 Evaluation Results

The evaluation results reported in Table 4.2 report the number and rate of detections and the number and rate of false alarms using thresholds estimated from the Edens Expressway with different false alarm penalty weights. The number of detected incidents ranges from 17 (19.5%) to 60 (69.0%) of the 87 incidents in the data. The number of false alarms ranges from 18 (0.020%) to 814 (0.923%). Since the false alarms are estimated on the condensed incident free data, the number of false alarms should be multiplied by the ratio of incident free time (184 hours) to incident free time used in the estimation (35 hours) to get the expected number of false alarms in this roadway. This works out to 95 false alarms for the algorithm based on the highest false alarm penalty weight (alpha=300) and 4279 false alarms for the algorithm estimated with the lowest penalty weight (alpha=50) Clearly, these are unacceptably large numbers of false alarms.

Table 4.2: Evaluation Results of Kennedy Expressway, Inbound

False Alarm Penalty Weight	Detection Rate (%)	Number of Detected Incident	False Alarm Rate (%)	Number of False Alarms	Mean Time To Detect (min.)
50	69.0	60	0.923	814	11.15
100	52.9	46	0.412	363	11.76
150	49.4	43	0.281	248	12.88
200	39.1	34	0.160	141	12.59
300	19.5	17	0.020	18	13.29

Table 4.3 compares the evaluation results on the Kennedy Expressway evaluation data

set with the estimation results on the Edens Expressway data set. The detection rates in the evaluation test are lower and the false alarms are higher for the evaluation data than for the estimation data set (except for the fifth threshold set, alpha equals 300, for which the false alarm rates are approximately equal). The mean time to detect is approximately 1 or 2 minutes greater for the evaluation data than for the estimation data in every threshold set except for the fifth threshold set where it increases by about l/2 minute.

Table 4.3: Comparison of Evaluation Results with Estimation Results

Threshold Set	False Alarm Penalty Weight	Comparison	Detection Rate (%)	False Alarm Rate (%)	Mean Time to Detect (min.)
1	50	Estimation (Edens)		0.603	
		Evaluation (Kennedy)	69.0	0.938	11.15
2	100	Estimation (Edens)	63.8		
		Evaluation (Kennedy)	52.9	0.412	11.76
3	150	Estimation (Edens)	56.5		
		Evaluation (Kennedy)	49.4	0.281	12.88
4	200	Estimation (Edens)	49.3	0.094	10.74
		Evaluation (Kennedy)	39.1	0.160	12.59
5	300	Estimation (Edens)		0.022	
		Evaluation (Kennedy)	19.5	0.020	13.29

Figure 4.2 shows the comparison of detection rates and false alarm rates between the estimation and evaluation results (the solid line connects the estimation points and the dotted line connects the evaluation observations; common numbers indicate pairs of points based on the same algorithm). It is apparent that the evaluation results are much worse than the estimation results (lower detection rate and/or higher false alarm rate in every case).
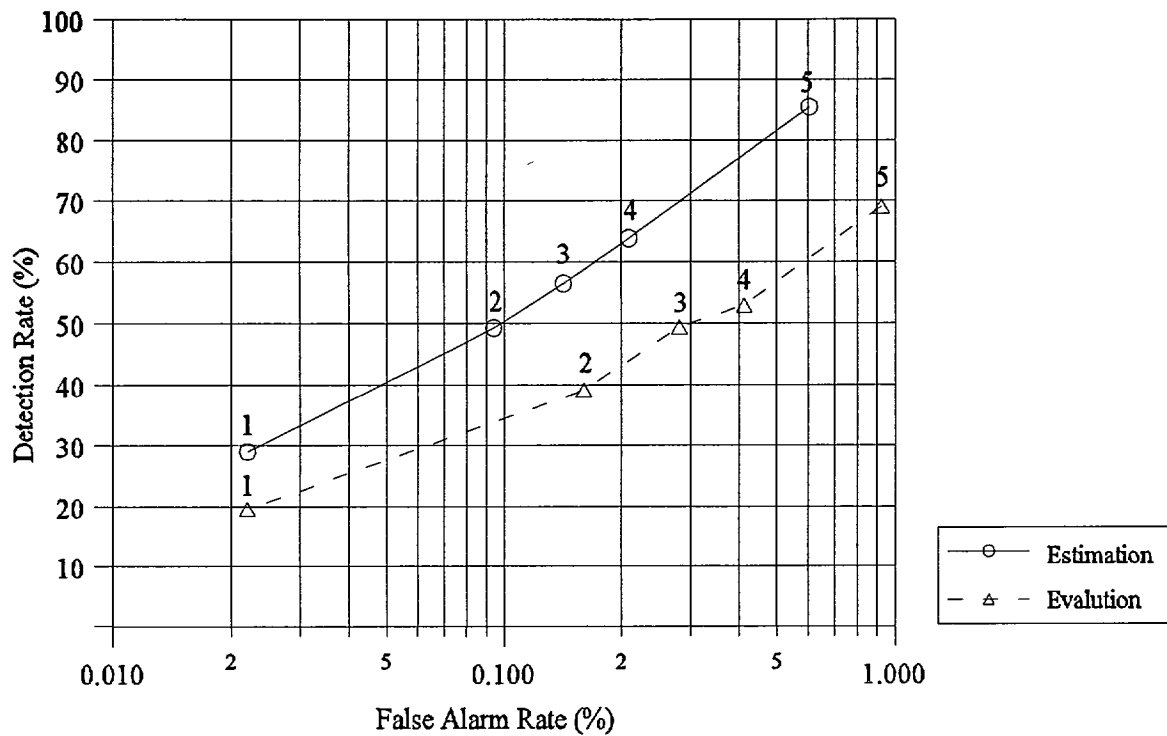
*The number above the symbol indicates the algorithm number.

Figure 4.2 Comparison of Evaluation Results with Estimation Results

There are two explanations for the differences between the estimation results of the

original models on the Edens Expressway and the evaluation results obtained when applying

these models to the Kennedy Expressway. These are (1) that it is more difficult to obtain good

incident discrimination on the Kennedy Expressway than on the Edens Expressway and (2) that

the model estimated on the Edens Expressway is not transferable to the Kennedy Expressway.

The first explanation is that the characteristics of non-incident flow conditions are more similar

to incident flow conditions on the Kennedy Expressway than on the Edens Expressway. This

could result from higher levels of congestion on the Kennedy Expressway or/and from using

data from a single detectorized lane to represent flow on four or five lanes on the Kennedy

Expressway compared to using a single detectorized lane to represent flow on three lanes on the Edens Expressway. The second explanation is that there are major differences in the best algorithm for the different expressways. That is, there is limited transferability of the estimated algorithm. Figure 4.2 shows the total difference between estimation on the Edens Expressway and application to the Kennedy Expressway; this difference includes both effects described above. Examination of Figure 4.3 indicates that a little more than half of this difference is attributable to the difference between roadways and the balance is attributable to differences in models.
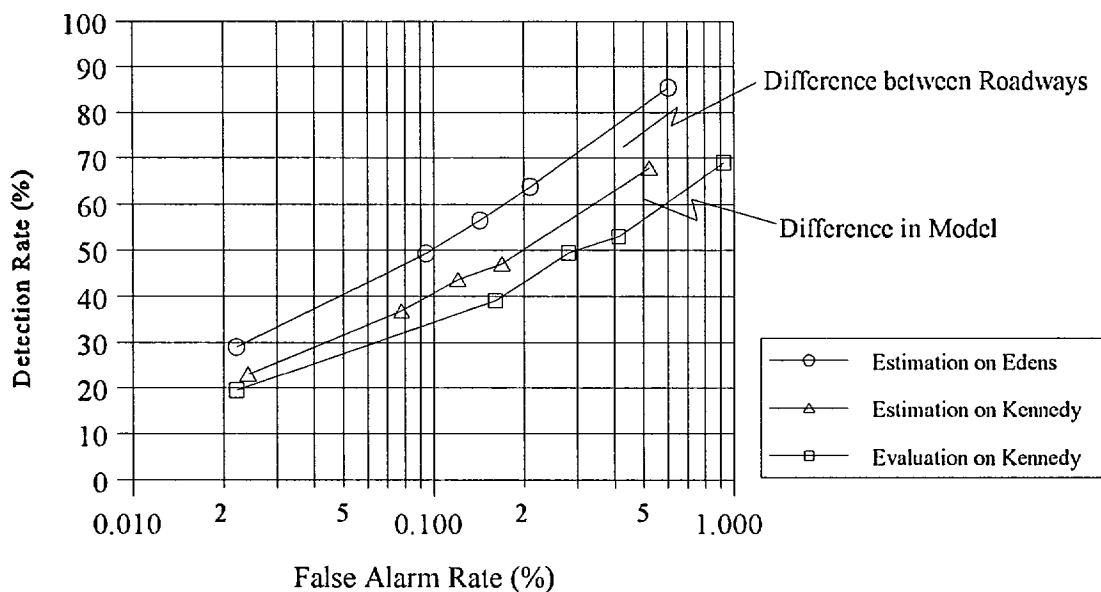
Figure 4.3   Comparison of Results: Estimation on Edens, Evaluation Application on Kennedy and Estimation on Kennedy

4.4 Summary of Expressway Incident Detection

The evaluation results obtained by applying the expressway incident detection algorithm on a new data set indicate that applying the algorithm to a different site causes a large drop in performance in terms of the detection rate, the false alarm rate, and the mean time to detect. The performance drop cannot be explained without substantial additional research; however, it appears to be due, in part, to the different traffic situation, including more congestion and more traffic lanes, on the evaluation roadway and, in part, to transfer between contexts indicating some lack of generalizability in algorithm parameters.

Both the estimation and evaluation results are unsatisfactory; that is, the number of false alarms generated by the algorithm is much greater than the number of incidents detected. These results indicate that great caution should be used in implementation of this automated incident detection algorithm in the absence of confirmation information from an independent source.

5. CONCLUSIONS

The incident detection component of *ADVANCE* was developed in the expectation that real time information will be valuable to all drivers in planning and executing selected travel routes. In particular, current information about the presence of incidents and their location will be valuable to local drivers, the primary users of *ADVANCE,* who are familiar with the network and have some knowledge of expected travel times under "normal conditions." This report describes the procedures and results of testing the effectiveness of arterial probe vehicle and fixed detector incident detection methods implemented in *ADVANCE* and expressway fixed detector incident detection methods considered for but not implemented in *ADVANCE.*

5.1   Evaluation of Arterial Incident Detection Using Fixed Detectors and Probe Vehicles

The *ADVANCE* incident detection system for arterial roads uses fixed detectors which provide occupancy and volume data, probe vehicles which provide link traversal data and anecdotal descriptions of events which are likely to impact traffic flow on arterial roads. For the purpose of evaluation, the anecdotal data provided by Northwest Central Dispatch (NWCD) is adopted as representing the true incident conditions of roadways in the portion of the *ADVANCE* area which is within emergency service jurisdictions supported by NWCD. The evaluation of both fixed detector and probe vehicle algorithms is undertaken by comparing arterial incidents identified by fixed detector and probe vehicle algorithms to incidents reported by NWCD. Additional analysis is undertaken to determine the extent to which modifications to the algorithms using evaluation data will improve their performance.

5.1.1 Evaluation of Arterial Fixed Detector Incident Detection Algorithm

The evaluation of the arterial fixed detector algorithm is undertaken by collecting data from loop detectors along Dundee Road and from NWCD logs for incident verification during **a** period of two months at twenty-two locations along Dundee Road. Of 141 incidents reported during this period, the algorithm detected only seven incidents (and 32 incident periods) while also reporting nine false alarms; the mean time to detect the detected incidents was approximately five minutes after the first report received by local emergency services through Northwest Central Dispatch. All of the detected incidents were incidents identified as major (not related to law enforcement). Consideration of alternative algorithms identified a change in specification, standardization of volume deviation and occupancy deviation by the variability of those measures at each station by time of day, which increased the number of detections **to 29** including 18 major incidents and 86 incident periods without producing any false alarms. The mean time to detect is approximately equal to the time of the first NWCD report and close to half of the detected incidents were detected before any report was received by local emergency services.

These results indicate substantial potential for the development of arterial incident detection algorithms based on data from fixed detectors. A first step toward realization of this result would be more extensive data collection and analysis of arterial detector data in a variety of environments with corresponding incident verification data.

5.1.2 Evaluation of Arterial Probe Vehicle Incident Detection Algorithm

The evaluation of the probe vehicle algorithm is based on comparison of link traversal data collected through the assignment of a fleet of vehicles to travel on incident links under incident and non-incident conditions to NWCD logs for incident verification.

The arterial probe vehicle algorithm implemented in *ADVANCE* was evaluated for a period of twenty days (ten days in August and ten days in November, 1995) within the *ADVANCE* area covered by Northwest Central Dispatch. Evaluation was based on the analysis of individual probe reports and sequences of three probe reports on the incident and adjacent links.

The three report algorithm identified six of eleven incidents, for which sequences of three reports were available, without any false alarms; the corresponding single report algorithm was not capable of detecting this share of incidents without reporting multiple false alarms.

An alternative algorithm which changed the specification by the addition of congestion distance deviation improved the effectiveness of the arterial fixed detector algorithm in terms of the number of incident traversals identified and the number of false alarms.

Both the evaluation and modification results support the contention that probe vehicle incident detection be based on the use of multiple reports to avoid the potential for numerous false alarms based on unusual readings from a single vehicle caused by reasons other than disruptions in traffic flow on a link.

Implementation of the probe vehicle arterial incident detection algorithm can only be expected to be successful if the number of vehicles equipped is large enough to ensure a reasonable likelihood of multiple probe vehicle reports on potential incident links during

relatively short time periods during peak travel conditions. Further development of the potential for incident identification through the use of probe vehicles would require a larger field test.

5.2   Expressway Incident Detect ion

Limited development of an incident detection capability for expressways in the *ADVANCE* and adjacent areas was based on the California incident detection algorithm using data from fixed detectors which are located at approximately one-half mile intervals for the center lane of each roadway. The estimated algorithm was unsatisfactory as the number of false alarms was much greater than the number of incidents detected at any reasonable level of detection. Nonetheless, this algorithm is included in the evaluation for completeness.

The evaluation of the expressway incident detection algorithm was undertaken by collecting automatic data from loop detectors along a different expressway and comparing incident detection results to incident confirmation data based on cellular phone and Emergency Traffic Patrol reports.

The evaluation results obtained by applying the expressway incident detection algorithm on a new data set indicate that applying the algorithm to a different site causes a large drop in performance in terms of the detection rate, the false alarm rate, and the mean time to detect. The performance drop is due, in part, to the different traffic situation, including more congestion and more traffic lanes, on the evaluation roadway and, in part, to transfer between contexts indicating some lack of generalizability in algorithm parameters.

Both the estimation and evaluation results are unsatisfactory; they indicate that the number of false alarms generated by the algorithm is likely to be much greater than the number

of incidents detected. These results indicate that great caution should be used in implementation of this automated incident detection algorithm in the absence of confirmation information from an independent source. This unsatisfactory performance compared to reported incident detection performance in other contexts may be due to limitations in the precision and completeness of incident information and reliance on single lane detectors rather than multiple lane detectors.

5.3   Conclusion

The results of this evaluation indicate a potential to develop and implement effective incident detection capabilities for use on arterial road networks based on either or both of fixed detector or probe vehicle data. However, considerable additional development, with field data is required to reach this potential.

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Appendix A: Detailed Probe Vehicle Evaluation Results

NU Inc. #: 1	NWCD Incident #: AHP953442
Date: 08/09/95	First report: 15:49 Clear: 17:31
Type: ACPD Inc.	Location: WB Rand, btw Wilke Hintz

Incident PV IDs: 41 , OA ,   ,   .

Follow-up PV IDs:
      Date: 08/21 ; 41 , 10 , 15 , 2B .
      Date: 08/23 ; OA , 1B ,   ,   .
      Date: 08/24 ; 23 , 57 , 2B ,   .
      Date: 08/25 ; 5C , 59 ,   ,   .
      Date: 11/15 ; 16 ,   ,   ,   .

Use distinct block for each link (and turning movement)

Segment #: 88d070-88d0ac   Direction: SEB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/8 ; FU Alarms/Traversals: 0/21 .
      Base (3 report): 0/6 ; FU Alarms/Traversals: 0/19 .
      Adj. (1 report):   ; FU Alarms/Traversals: .
      Adj. (3 report):   ; FU Alarms/Traversals: .
Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 88d0ac-88d226   Direction: SEB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Turn   .
Inc. Detections/Traversals:
      Base (1 report): 0/4 ; FU Alarms/Traversals: N/A .
      Base (3 report): 0/2 ; FU Alarms/Traversals: .
      Adj. (1 report):   ; FU Alarms/Traversals: .
      Adj. (3 report):   ; FU Alarms/Traversals: .
Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals .

Segment #: 88d0ac-88d2d0   Direction: SEB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through   .
Inc. Detections/Traversals:
      Base (1 report): 0/2 ; FU Alarms/Traversals: 0/22 .
      Base (3 report):   ; FU Alarms/Traversals: 0/20 .
      Adj. (1 report): 0/2 ; FU Alarms/Traversals: 0/22 .
      Adj. (3 report):   ; FU Alarms/Traversals: 0/20 .
Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: ___1___ | NWCD Incident #: ___AHP953442 1___][

Date: ___08/09/95___ First report: ___15:49___ Clear: ___17:01___

Type: ___ACPD___ | Inc. Location: ___WB Rand, btw Wilke & Hintz___

Segment #: ___8a 1044-8ce5c8___ Direction: ___SEB___
Link Location (Incident, Upstream, Downstream): ___UP1___ Turn: Through
Inc. Detections/Traversals:
    Base (1 report): ___0/8___ ; FU Alarms/Traversals: ___1/22___
    Base (3 report): ___0/6___ ; FU Alarms/Traversals: ___0/20___
    Adj. (1 report): ___018___ ; FU Alarms/Traversals: ___0/22___
    Adj. (3 report): ___O/6___ ; FU Alarms/Traversals: ___0/20___
Other observations (short link, data problems, etc.; use lines as needed)

Segment #: ___8d070-a 1044___ Direction: ___NWB___
Link Location: (Incident, Upstream, Downstream): ___INC___ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___2/9___ ; FU Alarms/Traversals: ___6/31___
    Base (3 report): ___0/7___ ; FU Alarms/Traversals: ___3/29___
    Adj. (1 report): ___0/9___ ; FU Alarms/Traversals: ___0/3 1___
    Adj. (3 report): ___0/7___ ; FU Alarms/Traversals: ___0/29___
Other observations (Short link, data problems, etc.; use lines as needed)

Segment #: ___8d0ac-8d070___ Direction: ___NWB___
Link Location (Incident, Upstream, Downstream): ___TNC___ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___l/10___ ; FU Alarms/Traversals: ___0/27___
    Base (3 report): ___3/8___ ; FU Alarms/Traversals: ___0/25___
    Adj. (1 report): ___6/10___ ; FU Alarms/Traversals: ___0/27___
    Adj. (3 report): ___7/8___ ; FU Alarms/Traversals: ___0/25___
Other observations (Short link, data problems, etc.; use lines as needed)

NU Inc. #: 2	NWCD Incident #: EGP9535364 (EGP 9535374)
Date: 08/09/95	First report: 15:12 (16:18) Clear: 16:05 (17:09)
Type: ACPD/I	Location: NB Elmhurst, btw Landmeier & Higgins

Incident PV IDs: 59 , 09 , _____ , _____ .

Follow-up PV IDs:
       Date: 08/21 ; 0A , 09 , 17 , 57 .
       Date: 08/22 ; 59 , _____ , _____ , _____ .
       Date: 08/23 ; 50 , 14 , _____ , _____ .
       Date: 08/24 ; 17 , 15 , _____ , _____ .
       Date: 08/25 ; 15 , 0A , _____ , _____ .
       Date: 11/07 ; 09 , 52 , _____ , _____ .

Use distinct block for each link (and turning movement)

Segment #: 89e584-90c0e   Direction: SB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/1 ; FU Alarms/Traversals: _____ .
      Base (3 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (1 report): 0/1 ; FU Alarms/Traversals: _____ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .
Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals .

Segment #: 89e584-90cf3   Direction: SB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/1 ; FU Alarms/Traversals: _____ .
      Base (3 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .
Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals .

Segment #: 9e584-908b7   Direction: NB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/3 ; FU Alarms/Traversals: 2/20 .
      Base (3 report): 0/1 ; FU Alarms/Traversals: 3/18 .
      Adj. (1 report): 0/3 ; FU Alarms/Traversals: 0/20 .
      Adj. (3 report): 0/1 ; FU Alarms/Traversals: 0/18 .
Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #:   2 | NWCD Incident #:   EGP9535364 (EGP 9535374) ||

Date: 08/09/95   First report: 15:12 (16:18)   Clear: 16:05 (17:09)

Type: ACPD/I   Inc. Location: NB Elmhurst. btw Landmeier
                                                & Higgins

Segment #:   890cf3-89e59a   Direction: NB
Link Location: **(Incident, Upstream, Downstream):**   UP 1   Turn: Turn
Inc. Detections/Traversals:
    Base (1 report):   N/A ; FU Alarms/Traversals: N/A
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(short link, data problems etc.; use lines as necdcd):** No CTT, no FU traversals.

Segment #:   9e59a-9e584 Direction: W B_____
Link Location: **(Incident, Upstream, Downstream):**   UP 1   Turn: Through
Inc. Detections/Traversals:
    Base (1 report):   0/l ; FU Alarms/Traversals: N/A
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(Short link, data problems, etc.; use lines as needed):**

NU Inc. #: 3	NWCD Incident #: None

Date: 08/09/95   First report: 15:27   Clear: 16:15

Type: Short Term Cons. | Location: WB Central, Central & Arlington Hts

Incident PV IDs: 41 ,   ,   ,   .

Follow-up PV IDs:

    Date: ;   ,   ,   ,   .

    Date: ;   ,   ,   ,   .

    Date: ;   ,   ,   ,   .

    Date: ;   ,   ,   ,   .

Use distinct block for each link (and turning movement)

Segment #: 8eea4-8ee90 Direction: WB .

Link Location: (Incident, Upstream, Downstream) : UP1   Turn: Through .

Inc. Detections/Traversals:

    Base (1 report): 0/3 ; FU Alarms/Traversals: .

    Base (3 report): 0/1 ; FU Alarms/Traversals: .

    Adj. (1 report):   ; FU Alarms/Traversals: .

    Adj. (3 report):   ; FU Alarms/Traversals: .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #:   8ee90-8eb93   Direction: WB .

Link Location: (Incident, Upstream, Downstream) : Cons Side   Turn:

Inc. Detections/Traversals:

    Base (1 report): 0/3 ; FU Alarms/Traversals: .

    Base (3 report): 0/1 ; FU Alarms/Traversals: .

    Adj. (1 report):   ; FU Alarms/Traversals: .

    Adj. (3 report):   ; FU Alarms/Traversals: .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #:   8ee82-8ee87   Direction: WB .

Link Location: (Incident, Upstream, Downstream) : DN2   Turn:

Inc. Detections/Traversals:

    Base (1 report): 1/1 ; FU Alarms/Traversals: .

    Base (3 report):   ; FU Alarms/Traversals: .

    Adj. (1 report):   ; FU Alarms/Traversals: .

    Adj. (3 report):   ; FU Alarms/Traversals: .

Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: 3	NWCD Incident #: None
Date: 08/09/95 First report: 15:27 Clear: 16: 15	
Type: Short Term Cons.	Inc. Location: WB Central, Central & Arlington Hts.

Segment #: 8ee89-8fl8c   Direction: EB
Link Location: **(Incident, Upstream, Downstream):**   Cons. Side   Turn : _____
Inc. Detections/Traversals:
    Base (1 report): _0/1_ ; FU Alarms/Traversals: _____
    Base (3 report): _____ ; FU Alarms/Traversals: _____
    Adj. (1 report): _____ ; FU Alarms/Traversals: _____
    Adj. (3 report): _____ ; FU Alarms/Traversals: _____
Other observations **(short link. dnt? problems, etc., use lines as needed)**

Segment #: 8ee87-8ee82   Direction: EB
Link Location: **(Incident, Upstream, Downstream):**   _____   Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _0/1_ ; FU Alarms/Traversals: _____
    Base (3 report): _____ ; FU Alarms/Traversals: _____
    Adj. (1 report): _____ ; FU Alarms/Traversals: _____
    Adj. (3 report): _____ ; FU Alarms/Traversals: _____
Other observations **(short link. data problems, etc., use lines as needed)**

NU Inc. #: 4	NWCD Incident #: AHF950456 1 (AHP9534591)

Date: 08/09/95	First report: 16:38 Clear: 16:51 (18:01)

Type: ACPI	Inc. Location: Oakton. btw Elizabeth & Badger

Incident PV IDs: 15 , 17 , 57 ,   .

Follow-up PV IDs:

      Date: 11/07 ;   09 , 52 ,   ,   .

      Date: 11/15 ;   17 , 0B, 57 ,   .

      Date: 11/17 ;   11 , 4B, 14 ,   .

Use distinct block for each link (and turning movement)

Segment #: a6f2a-905f6   Direction: WB .

Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .

Inc. Detections/Traversals:

      Base (1 report): 1/2 ; FU Alarms/Traversals: 0/35 .

      Base (3 report):   ; FU Alarms/Traversals: 0/33 .

      Adj. (1 report):   ; FU Alarms/Traversals: .

      Adj. (3 report):   ; FU Alarms/Traversals: .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 905f6-905fe   Direction: WB .

Link Location: (Incident, Upstream, Downstream) : DN1   Turn: Through.

Inc. Detections/Traversals:

      Base (1 report): 2/3 ; FU Alarms/Traversals: 27/38 .

      Base (3 report): 0/1 ; FU Alarms/Traversals: 32/36 .

      Adj. (1 report): 0/3 ; FU Alarms/Traversals: 2/38 .

      Adj. (3 report): 0/1 ; FU Alarms/Traversals: 0/36 .

Other observations (short link, data problems, etc.; use lines as needed) : Lots of "low-speed" link_tr in FU traversals.

Segment #: 8905f6-8a6f2a   Direction: EB .

Link Location: (Incident, Upstream, Downstream) : UP1   Turn: Through.

Inc. Detections/Traversals:

      Base (1 report): 0/1 ; FU Alarms/Traversals: 0/42 .

      Base (3 report):   ; FU Alarms/Traversals: 0/40 .

      Adj. (1 report): 0/1 ; FU Alarms/Traversals: 0/42 .

      Adj. (3 report):   ; FU Alarms/Traversals: 0/40 .

Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: ___4___	] NWCD Incident #: ___AHF950456 1 (AHP953459 1)___
Date: ___08/10/95___ First report: 16:38 Clear: ___16:51 (18:01)___	
Type: ___ACPT___	Inc. Location: ___Oakton. btw Elizabeth & Badger___

Segment #: ___8a6f2a-8905ad___ Direction: __EB___
Link Location: (Incident, Upstream, Downstream): __INC___ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): ___0/2___; FU Alarms/Traversals: ___0/15___
   Base (3 report): _____; FU Alarms/Traversals: 0/13
   Adj. (1 report): __0/2___; FU Alarms/Traversals: 0/15
   Adj. (3 report): _____; FU Alarms/Traversals: ___0/13___
Other observations (short link, data problems. etc.; use lincs as needed)

NU Inc. #: 5	NWCD Incident #: None

Date: 08/10/95	First report: 15:10	Clear: 15:25

Type: Stalled Freight Train	Inc. Location: Hintz at RR track, btw Wheeling & Glenn

Incident PV IDs: 57 , 0B , 10 , 17 .

Follow-up PV IDs:

Date: 8/14 ; 5C , 0D , 14 , 50 , 17 , 1B ,

Date: 8/16 ; 45 , 5C , 3E , 1A , 15 , 10 ,

0E , 0B , 11 , 0A ,

Date: 8/17 ; 10 , 41 , 50 , .

Date: 11/21 ; 2B , , , .

Use distinct block for each link (and turning movement)

Segment #: 88d023-88d20b　　　Direction: EB .

Link Location: (Incident, Upstream, Downstream) : INC　　Turn: Through .

Inc. Detections/Traversals:

Base (1 report): 0/6 ; FU Alarms/Traversals: 0/16 .

Base (3 report): 0/4 ; FU Alarms/Traversals: 0/14 .

Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .

Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 88d1fe-88d203　　　Direction: EB .

Link Location: (Incident, Upstream, Downstream) : UP1　　Turn: Through.

Inc. Detections/Traversals:

Base (1 report): ____ ; FU Alarms/Traversals: 0/14 .

Base (3 report): 0/1 ; FU Alarms/Traversals: 0/12 .

Adj. (1 report): ____ ; FU Alarms/Traversals: 0/14 .

Adj. (3 report): 0/1 ; FU Alarms/Traversals: 0/12 .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 8d203-8d8f3　　　Direction: WB .

Link Location: (Incident, Upstream, Downstream) : INC　　Turn: Turn .

Inc. Detections/Traversals:

Base (1 report): 1/2 ; FU Alarms/Traversals: 0/9 .

Base (3 report): ____ ; FU Alarms/Traversals: 0/7 .

Adj. (1 report): 1/2 ; FU Alarms/Traversals: 0/9 .

Adj. (3 report): ____ ; FU Alarms/Traversals: 0/7 .

Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: 5	NWCD Incident #: None

Date: 08/10/95 First report: 15: 10 Clear: 15:25	

Type: Stalled Freight Train	Inc. Location: Hintz at RR track, btw Wheeling & Glenn

Segment #: 8d203-8d 1 fe Direction: WB

Link Location: (Incident, Upstream, Downstream): INC Turn: Through

Inc. Detections/Traversals:

    Base (1 report): 2/6 ; FU Alarms/Traversals: 0/28

    Base (3 report): 1/4 ; FU Alarms/Traversals: 0/26

    Adj. (1 report): 1/6 ; FU Alarms/Traversals: 0/28

    Adj. (3 report): 1/4 ; FU Alarms/Traversals: 0/26

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 8d20b-8d203 Direction: WB

Link Location: (Incident, Upstream, Downstream): UP 1 Turn:

Inc. Detections/Traversals:

    Base (1 report): 0/2 ; FU Alarms/Traversals: 0/5

    Base (3 report): ; FU Alarms/Traversals: 0/3

    Adj. (1 report): 0/2 ; FU Alarms/Traversals: 0/5

    Adj. (3 report): ; FU Alarms/Traversals: 0/3

Other observations (short link, data problems, etc., use lines as needed)

NU Inc. #: __6__	NWCD Incident #: __None__

Date: __08/11/95__   First report: __15:45__   Clear: __16:55__

Type: <u>Repair Truck</u> | Inc. Location: <u>SB Hintz, Hintz & Arlington Hts.</u>

Incident PV IDs: __50__ , __15__ , ____ , ____ .

Follow-up PV IDs:

       Date: __8/23__ ;   __0A__ , ____ , ____ , ____ .

       Date: __8/24__ ;   __57__ , __2B__ , ____ , ____ .

       Date: __8/25__ ;   __59__ , __5C__ , ____ , ____ .

       Date: __11/07__ ;   __09__ , __5A__ , ____ , ____ .

       Date: __11/15__ ;   __16__ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: __88cebf-8d2a8__   Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:

       Base (1 report): __0/5__ ; FU Alarms/Traversals: __0/17__ .

       Base (3 report): __0/3__ ; FU Alarms/Traversals: __0/15__ .

       Adj. (1 report): __0/5__ ; FU Alarms/Traversals: __0/17__ .

       Adj. (3 report): __0/3__ ; FU Alarms/Traversals: __0/15__ .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: __892387-88cbef__   Direction: __EB__ .

Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through.__

Inc. Detections/Traversals:

       Base (1 report): __0/4__ ; FU Alarms/Traversals: __0/16__ .

       Base (3 report): __0/2__ ; FU Alarms/Traversals: __0/14__ .

       Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .

       Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: __88cbef-92387__   Direction: __NB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:

       Base (1 report): __0/6__ ; FU Alarms/Traversals: __0/35__ .

       Base (3 report): __0/4__ ; FU Alarms/Traversals: __0/33__ .

       Adj. (1 report): __0/6__ ; FU Alarms/Traversals: __0/35__ .

       Adj. (3 report): __0/4__ ; FU Alarms/Traversals: __0/33__ .

Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: ___6___	NWCD Incident #: ___None___
Date: ___08/11/95___ First report: ___15:45___ Clear: ___16:55___	
Type: ___Repair Truck___	Inc. Location: ___SB Hintz. Hintz & Arlington Hts.___

Segment #: ___88d2a8-8cebf___   D i r e c t i o n: N B

Link Location: (Incident, Upstream, Downstream):   UP| Turn: ___Through___

Inc. Detections/Traversals:

    Base (1 report) : ___0/7___; FU Alarms/Traversals: 5/35

    Base (3 report): ___0/5___; FU Alarms/Traversals: 3/33

    Adj. (1 report): ___0/7___; FU Alarms/Traversals: 0/35

    Adj. (3 report): ___0/5___; FU Alarms/Traversals: 0/33

Other observations (short link data problems, etc., use lines as needed)

NU Inc. #: 7	NWCD Incident #: DAP9534050

Date: 08/11/95   First report: 17:53   Clear: 18:32

Type: ACPD	Inc. Location: SB Hintz, Hintz & Arlington Hts.

Incident PV IDs: 41 , 50 , ____ , ____ .

Follow-up PV IDs:
      Date: 08/15 ;   0B , 2B , 10 , 11 , 19 , 5C ,
      Date: 08/18 ;   1A , 0B , 28 , 09 .
      Date: 08/29 ;   1B , 5C , 10 , 14 , 57 ,
      Date: 11/09 ;   2B , 52 , ____ , ____ .
      Date: 11/14 ;   0B , 16 , 2B , 69 .
      Date: 11/16 ;   2B , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: 89c51a-88c4a2   Direction: EB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Turn .
Inc. Detections/Traversals:
      Base (1 report): 0/1 ; FU Alarms/Traversals: N/A .
      Base (3 report): ____ ; FU Alarms/Traversals: ____ .
      Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .
      Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .
Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals

Segment #: 892387-88cbef   Direction: EB .
Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/1 ; FU Alarms/Traversals: 0/1 .
      Base (3 report): ____ ; FU Alarms/Traversals: ____ .
      Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .
      Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .
Other observations (short link, data problems, etc.; use lines as needed)

Segment #: 89c5dc-89c51a   Direction: EB .
Link Location: (Incident, Upstream, Downstream) : UP1   Turn: Through .
Inc. Detections/Traversals:
      Base (1 report): 0/2 ; FU Alarms/Traversals: 0/41 .
      Base (3 report): ____ ; FU Alarms/Traversals: 0/39 .
      Adj. (1 report): 0/2 ; FU Alarms/Traversals: 0/41 .
      Adj. (3 report): ____ ; FU Alarms/Traversals: 0/39 .
Other observations (short link, data problems, etc.; use lines as needed) :

NU Inc. #: ___7___	NWCD Incident #: ___DAP9534050___

Date: ___08/11/95___ First report: ___17:53___ Clear: ___18:32___

Type: ___ACPD___	Inc. Location: ___EB Lake Cook, Lake & Corporate Dr.___

Segment #: ___9c5 1 a-9c5dc___ Direction: ___W B___
Link Location: (Incident, Upstream, Downstream): ___INC___ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): ___0/4___; FU Alarms/Traversals: __0/23__
   Base (3 report): ___0/2___; FU Alarms/Traversals: __1 0/2__
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (short link. data problems etc., use lines as needed)

Segment #: ___8c4a2-9c5 1 a___ Direction: ___SB/WB___
Link Location: (Incident, Upstream, Downstream) : ___UP 1___ Turn: ___Turn___
Inc. Detections/Traversals:
   Base (1 report): ___0/1___; FU Alarms/Traversals: ___N / A___
   Base (3 report): _____; FU Alarms/Traversals: _____
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (short link, dala problems, etc., useq lines as needed):

Segment #: ___8c4a4-9c5 1 a___ Direction: ___W B___
Link Location: (Incident, Upstream, Downstream): ___UP 1___ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report) : ___0/1___; FU Alarms/Traversals: ___N / A___
   Base (3 report): _____; FU Alarms/Traversals: _____
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short link, data problems etc.' use lines as needed): No FU traversals ___.

NU Inc. #: __8__	NWCD Incident #: ___MPP9542752 (MPF9503737)___

Date: __08/21/95__	First report: __16:52__	Clear: __17:43__

Type: __ACPI__	Inc. Location: __NWB Algonquin, Algonquin & Busse__

Incident PV IDs: __17__ , __57__ , __0A__ .

Follow-up PV IDs:
      Date: __08/22__ ;   __0A__ , __0B__ , _____ , _____ .
      Date: __08/23__ ;   __15__ , __41__ , __57__ , _____ .
      Date: __08/24__ ;   __14__ , __41__ , _____ , _____ .

Use distinct block for each link (and turning movement)

Segment #: __88ff7a-8ff7b__   Direction: __SB/EB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Turn__ .
Inc. Detections/Traversals:
      Base (1 report): __0/1__ ; FU Alarms/Traversals: __N/A__ .
      Base (3 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .
Other observations (short link, data problems, etc.; use lines as needed) : __No FU traversals__

Segment #: __88ff7b-89e6da__   Direction: __EB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Turn__ .
Inc. Detections/Traversals:
      Base (1 report): __1/1__ ; FU Alarms/Traversals: __N/A__ .
      Base (3 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .
Other observations (short link, data problems, etc.; use lines as needed) : __Short link combined; one erratic CTT in Inc. traversals (561 mph)__

Segment #: __88ff7b-89e6d5__   Direction: __EB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __0/2__ ; FU Alarms/Traversals: __2/6__ .
      Base (3 report): _____ ; FU Alarms/Traversals: __0/4__ .
      Adj. (1 report): __0/2__ ; FU Alarms/Traversals: __0/6__ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: __0/4__ .
Other observations (short link, data problems, etc.; use lines as needed) : __Short link combined; one erratic CTT (92 mph) in Inc. & one erratic CTTs (162 mph) in FU traversals.__

NU Inc. #: ___8___	NWCD Incident #: ___MPP9542752 (MPF9503737)___

Date: ___08/21/95___ First report: ___16:52___ Clear: ___17:43___

Type: ___ACPT___	Inc. Location: ___NWB Algonquin. Algonquin & Busse___

Segment #: ___9e6d58ff7a___ Direction: _WB__
Link Location: (Incident, Upstream, Downstream): ___UP1 Turn: ___Turn___
Inc. Detections/Traversals:
   Base (1 report): __1/2__; FU Alarms/Traversals: _N / A_
   Base (3 report): _____; FU Alarms/Traversals: _____
   Adj. (1 report): __1/2__; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Shorl link, data problems, etc., use lines as needed): Short link combined: one erratic
CTT (70 mph) in Inc. traversals .

Segment #: 9e6d5-8ff2b___ Direction: _WB__
Link Location: (Incident, Upstream, Downstream): _UP 1_ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): __1/1__; FU Alarms/Traversals: __4/6__
   Base (3 report): _____; FU Alarms/Traversals: _1/4_
   Adj. (1 report): __0/1__; FU Alarms/Traversals: 0/6__
   Adj. (3 report): _____; FU Alarms/Traversals: 0/4__
Other observations (Short link, data problems, etc., use lines as needed): Short link combined: one erratic
CTT 1668.86 mph) in Inc. & 4 erratic CTTs in FU traversals.

NU Inc. #: __9__	NWCD Incident #: EGP9537699

Date: __08/23/95__	First report: __14:57__	Clear: __15:58__

Type: __ACPD__	Inc. Location: WB Landmeier, Landmeier & Lively

Incident PV IDs: __2B__ , __14__ , ____ , ____ .

Follow-up PV IDs:
     Date: __08/25__ ; __50__ , __15__ , __0D__ , ____ .
     Date: ____ ; ____ , ____ , ____ , ____ .
     Date: ____ ; ____ , ____ , ____ , ____ .
     Date: ____ ; ____ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: 90abe-890b13	Direction: __SB/EB__ .

Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Turn__ .

Inc. Detections/Traversals:
     Base (1 report): __0/1__ ; FU Alarms/Traversals: __N/A__ .
     Base (3 report): ____ ; FU Alarms/Traversals: ____ .
     Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals

Segment #: 890992-890b13	Direction: __EB__ .

Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .

Inc. Detections/Traversals:
     Base (1 report): __0/1__ ; FU Alarms/Traversals: __0/3__ .
     Base (3 report): ____ ; FU Alarms/Traversals: __0/1__ .
     Adj. (1 report): __0/1__ ; FU Alarms/Traversals: __0/3__ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: __0/1__ .

Other observations (short link, data problems, etc.; use lines as needed) :

Segment #: 890b13-890ccc	Direction: __EB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:
     Base (1 report): __0/1__ ; FU Alarms/Traversals: __0/2__ .
     Base (3 report): ____ ; FU Alarms/Traversals: ____ .
     Adj. (1 report): __0/1__ ; FU Alarms/Traversals: __0/2__ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed)

NU Inc. #: ___9___	NWCD Incident #: ___EGP9537699___
Date: ___08/23/95___ First report: 14:57 Clear: ___15:58___	
Type: ___ACPD___	Inc. Location: ___WB Landmeier. Landmeier & Lively___

Segment #: ___89e727-90b 13___ Direction: ___SB/WB___
Link Location (Incidcnt, Upstream, Downstream): ___UP1___ Turn: ___Turn___
Inc. Detections/Traversals:
    Base (1 report): ___0/1___; FU Alarms/Traversals: ___N/A___
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short link, data problems, etc., use lines as needed): No FU traversals.

Segment #: ___90b 13-90992___ Direction: WB
Link Location: (Incident. Upstream, Downstream): ___INC___ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___0/2___; FU Alarms/Traversals: ___0/3___
    Base (3 report): _____; FU Alarms/Traversals: ___0/1___
    Adj. (1 report): ___0/2___; FU Alarms/Traversals: ___0/3___
    Adj. (3 report): _____; FU Alarms/Traversals: ___0/1___
Other observations (Shorl link, data problems, etc., use lines as needed)

Segment #: ___90b 13-890abe___ Direction: WB
Link Location: (Incident, Upstream, Downstream): ___TNC___ Turn: ___Turn___
Inc. Detections/Traversals:
    Base (1 report): ___1/1___; FU Alarms/Traversals: ___0/1___
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (short link, data problems, etc. ; use lines as needed): Because of time gaps, not many Inc.
traversals were found in this case.

NU Inc. #: __10__	NWCD Incident #: EGP9537888

Date: __08/24/95__ First report: __14:57 (15:19 field report)__ Clear: __15:02 (15:19 field report)__

Type: __LMAL__	Inc. Location: Busse, Busse & Devon

Incident PV IDs: __15__ , __0A__ , ____ , ____ .

Follow-up PV IDs:

Date: __08/25__ ; __19__ , __0A__ , ____ , ____ .

Date: ____ ; ____ , ____ , ____ , ____ .

Date: ____ ; ____ , ____ , ____ , ____ .

Date: ____ ; ____ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: __8a60c6-a6381__   Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:

Base (1 report): __3/5__ ; FU Alarms/Traversals: __0/7__ .

Base (3 report): __3/3__ ; FU Alarms/Traversals: __0/5__ .

Adj. (1 report): __1/5__ ; FU Alarms/Traversals: __0/7__ .

Adj. (3 report): __3/3__ ; FU Alarms/Traversals: __0/5__ .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: __8a5dff-8a60c6__   Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .

Inc. Detections/Traversals:

Base (1 report): __0/5__ ; FU Alarms/Traversals: __0/7__ .

Base (3 report): __0/3__ ; FU Alarms/Traversals: __0/5__ .

Adj. (1 report): __2/5__ ; FU Alarms/Traversals: __0/7__ .

Adj. (3 report): __2/3__ ; FU Alarms/Traversals: __0/5__ .

Other observations (short link, data problems, etc.; use lines as needed) :

Segment #: __a6381-926c5f__   Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __DN1__   Turn: __Turn__ .

Inc. Detections/Traversals:

Base (1 report): __1/2__ ; FU Alarms/Traversals: __N/A__ .

Base (3 report): ____ ; FU Alarms/Traversals: ____ .

Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .

Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed) : No FU traversals.

NU Inc. #: 10	NWCD Incident #: EGP9537888

Date: 08/24/95 First report: 14:57 (15: 19 field report) Clear: 15:02 (16:25 field report)

Type: LMAL	Inc. Location: Busse. Busse & Devon

Segment #: a6381-129516 Direction: S   B
Link Location: (Incident, Upstream, Downstream): DN 1   Turn: Through
Inc. Detections/Traversals:
    Base (1 report): 3/3 ; FU Alarms/Traversals: 3/7
    Base (3 report): 1/1 ; FU Alarms/Traversals: 4/5
    Adj. (1 report): 0/3 ; FU Alarms/Traversals: 0/7
    Adj. (3 report): 0/1 ; FU Alarms/Traversals: 0/5
Other observations (short link, data problems, etc.; use lines as needed)

Segment #: a60c6-a5dff Direction: N   B
Link Location: (Incident, Upstream, Downstream): INC Turn: Through
Inc. Detections/Traversals:
    Base (1 report): 0/5 ; FU Alarms/Traversals: 0/7
    Base (3 report): 0/3 ; FU Alarms/Traversals: 0/5
    Adj. (1 report): 1/5 ; FU Alarms/Traversals: 0/7
    Adj. (3 report): 0/3 ; FU Alarms/Traversals: 0/5
Other observations (Short link, data problems etc., use lines as needed)

NU Inc. #: __11__	NWCD Incident #: EGF950502

Date: __08/22/95__	First report: __16:07__	Clear: __16:46__ .

Type: __ACPI__	Inc. Location: Busse, Oakton & Howard

Incident PV IDs: __41__ , __09__ , ____ , ____ .

Follow-up PV IDs:
> Date: ____ ;   ____ , ____ , ____ , ____ .
> Date: ____ ;   ____ , ____ , ____ , ____ .
> Date: ____ ;   ____ , ____ , ____ , ____ .
> Date: ____ ;   ____ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: _____   Direction: ____ .
Link Location: (Incident, Upstream, Downstream) : ____   Turn: _____ .
Inc. Detections/Traversals:
> Base (1 report): ____ ; FU Alarms/Traversals: ____ .
> Base (3 report): ____ ; FU Alarms/Traversals: ____ .
> Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .
> Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed)

Segment #: _____   Direction: ____ .
Link Location: (Incident, Upstream, Downstream) : ____   Turn: _____ .
Inc. Detections/Traversals:
> Base (1 report): ____ ; FU Alarms/Traversals: ____ .
> Base (3 report): ____ ; FU Alarms/Traversals: ____ .
> Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .
> Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed)

NU Inc. #: __12__	NWCD Incident #: AHP9550091

Date: __11/20/95__   First report: __13:40__   Clear: __14:09__

Type: __LMAL__ | Inc. Location: WB Algonquin, Algonguin & Wilke

Incident PV IDs: __1B__ , __11__ , ____ , ____ .

Follow-up PV IDs:
      Date: __11/07__ ;   __52__ , __0B__ , __09__ , ____ .
      Date: __11/08__ ;   __0B__ , __0A__ , __19__ , ____ .
      Date: __11/09__ ;   __5A__ , __1B__ , __11__ , __19__ .
      Date: __11/13__ ;   __2B__ , __5A__ , ____ , ____ .
      Date: __11/14__ ;   __32__ , __19__ , __2B__ , ____ .
      Date: __11/15__ ;   __0B__ , __5A__ , ____ , ____ .
      Date: __11/17__ ;   __4B__ , __5A__ , ____ , ____ .
      Date: __11/21__ ;   __14__ , __19__ , __44__ , __11__ .

Use distinct block for each link (and turning movement)

Segment #: 88fl27-88f443   Direction: __EB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:
      Base (1 report): __0/3__ ; FU Alarms/Traversals: __0/32__ .
      Base (3 report): __0/1__ ; FU Alarms/Traversals: __0/30__ .
      Adj. (1 report): __1/3__ ; FU Alarms/Traversals: __0/32__ .
      Adj. (3 report): __1/1__ ; FU Alarms/Traversals: __0/30__ .

Other observations (short link, data problems, etc.; use lines as needed) : Several erratic link_tr in FU traversals.

Segment #: 88f443-89e87c   Direction: __SEB__ .

Link Location: (Incident, Upstream, Downstream) : __DN__   Turn: __Through__ .

Inc. Detections/Traversals:
      Base (1 report): __1/2__ ; FU Alarms/Traversals: __10/42__ .
      Base (3 report): ____ ; FU Alarms/Traversals: __7/40__ .
      Adj. (1 report): __0/2__ ; FU Alarms/Traversals: __0/42__ .
      Adj. (3 report): ____ ; FU Alarms/Traversals: __0/40__ .

Other observations (short link, data problems, etc.; use lines as needed) : Short link combined; lots of erratic CTTs in FU traversals.

NU Inc. #: _____12_____	NWCD Incident #: _____AHP955009 1_____
Date: __11/20/95__ First report: __13:40__ Clear: ___14:09___	
Type: __LMAL__	Inc. Location: __WB Algonquin. Algonquin & Wilke__

Segment #: __8f443-8f 127__   D i r e c t i o n: W B

Link Location: **(Incident. Upstream, Downstream)** : __INC__ Turn: __Through__

Inc. Detections/Traversals:

    Base (1 report): __2/3__ ; FU Alarms/Traversals: __0/46__

    Base (3 report): __1/1__ ; FU Alarms/Traversals: __0/44__

    Adj. (1 report): __2/3__ ; FU Alarms/Traversals: __0146__

    Adj. (3 report): __1/1__ ; FU Alarms/Traversals: __0/44__

Other observations **(Short link, data problems, etc.; use lines as needed)**

NU Inc. #: __13____	NWCD Incident #: __MPF9505039 (MPF9557289)__

Date: _11/08/95_	First report: __17:01__	Clear: ___18:20____

Type: _ACPI_	Inc. Location: _WB Euclid, Euclid & Rand_

Incident PV IDs: __57__ , ____ , ____ , ____ .

Follow-up PV IDs:
     Date: _08/15_ ;   _28_ , _0D_ , _41_ , ____ .
     Date: _08/17_ ;   _17_ , ____ , ____ , ____ .
     Date: _08/21_ ;   _15_ , _2B_ , _41_ , ____ .
     Date: _08/28_ ;   _59_ , _0A_ , _45_ , _42_ .
     Date: _11/07_ ;   _14_ , _19_ , ____ , ____ .
     Date: _11/21_ ;   _54_ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: _9e80c-89e809_   Direction: __WB_ .
Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: _Turn_ .
Inc. Detections/Traversals:
     Base (1 report): _2/2_ ; FU Alarms/Traversals: _0/2_ .
     Base (3 report): ____ ; FU Alarms/Traversals: ____ .
     Adj. (1 report): _2/2_ ; FU Alarms/Traversals: _0/2_ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .
Other observations (short link, data problems, etc.; use lines as needed) : Short link combined

Segment #: _9e80c-9e74b_   Direction: __WB_ .
Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: _Through_ .
Inc. Detections/Traversals:
     Base (1 report): _1/2_ ; FU Alarms/Traversals: _0/20_ .
     Base (3 report): ____ ; FU Alarms/Traversals: _0/18_ .
     Adj. (1 report): _2/2_ ; FU Alarms/Traversals: _0/20_ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: _0/18_ .
Other observations (short link, data problems, etc.; use lines as needed) : Short link combined, one erratic CTT (70 mph) in Inc. traversals.

Segment #: _8e42f-9e80c_   Direction: __WB_ .
Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: _Through_ .
Inc. Detections/Traversals:
     Base (1 report): _1/2_ ; FU Alarms/Traversals: _14/39_ .
     Base (3 report): ____ ; FU Alarms/Traversals: _15/37_ .
     Adj. (1 report): _0/2_ ; FU Alarms/Traversals: _0/39_ .
     Adj. (3 report): ____ ; FU Alarms/Traversals: _0/37_ .
Other observations (short link, data problems, etc.; use lines as needed) : Short link combined, few erratic CTTs in both Inc. & FU traversals.

NU Inc. #: ___13___	NWCD Incident #: ___MPF9505039 (MPF9557289)___
Date: ___11 /08/95___ First report: 17:0l___ Clear: ___18:20___	
Type: ___ACPI___	Inc. Location: ___WB Euclid. Euclid & Rand___

Segment #: 89e74b-926880___ Direction: E___ B
Link Location: (Incident. Upstream, Downstream): ___INC Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___0/2___; FU Alarms/Traversals: ___0/25___
    Base (3 report): _____; FU Alarms/Traversals: 0/23___
    Adj. (1 report): ___0/2___; FU Alarms/Traversals: ___0/25___
    Adj. (3 report): _____; FU Alarms/Traversals: 0/23___
Other observations (Short link, data problems, etc.; use lines as needed): Short link combined.

NU Inc. #: __14__	NWCD Incident #: __MPP9557435 (MPF9505048)__

Date: __11/09/95__	First report: __14:53__	Clear: __16:11__

Type: __ACPI__	Inc. Location: __SB Main. Main & NW Hwy__

Incident PV IDs: __2B__ , __57__ , __16__ , ____ .

Follow-up PV IDs:
      Date: __08/17__ ;   __5C__ , __50__ , __59__ , ____ .
      Date: __11/07__ ;   __14__ , ____ , ____ , ____ .
      Date: __11/08__ ;   __16__ , ____ , ____ , ____ .
      Date: __11/14__ ;   __5A__ , __57__ , ____ , ____ .
      Date: __11/15__ ;   __16__ , __19__ , __14__ , __52__ .

Use distinct block for each link (and turning movement)

Segment #: __88ec8f-8efd8__   Direction: __SB__ .
Link Location: (Incident, Upstream, Downstream) : __UP2__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __0/1__ ; FU Alarms/Traversals: __0/36__ .
      Base (3 report): ____ ; FU Alarms/Traversals: __0/34__ .
      Adj. (1 report): __0/1__ ; FU Alarms/Traversals: __0/36__ .
      Adj. (3 report): ____ ; FU Alarms/Traversals: __0/34__ .
Other observations (short link, data problems, etc.; use lines as needed) : __The traversal on Main.__

Segment #: __88ec8f-8eebc__   Direction: __SB__ .
Link Location: (Incident, Upstream, Downstream) : __UP2__   Turn: __Turn__ .
Inc. Detections/Traversals:
      Base (1 report): __0/4__ ; FU Alarms/Traversals: __0/36__ .
      Base (3 report): __0/2__ ; FU Alarms/Traversals: __0/34__ .
      Adj. (1 report): __0/4__ ; FU Alarms/Traversals: __0/36__ .
      Adj. (3 report): __0/2__ ; FU Alarms/Traversals: __0/34__ .
Other observations (short link, data problems, etc.; use lines as needed) : __The traversal on Main.__

Segment #: __8f00c-8ef30__   Direction: __WB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __1/5__ ; FU Alarms/Traversals: __0/3__ .
      Base (3 report): __0/3__ ; FU Alarms/Traversals: __0/1__ .
      Adj. (1 report): __0/5__ ; FU Alarms/Traversals: __0/3__ .
      Adj. (3 report): __0/3__ ; FU Alarms/Traversals: __0/1__ .
Other observations (short link, data problems, etc.; use lines as needed): __The traversal on NW Hwy.__

NU Inc. #: 14	NWCD Incident #: MPP9557435 (MPF9505048)
Date: 11 /09/95 First report: 14:53 Clear: 16:ll	
Type: ACPI	Inc. Location: SB Main, Main & NW Hwy

Segment #:   8f056-8f00c   Direction: WB
Link Location: (Incidcnt, Upstream, Downstream):   UP2   Turn: Through
Inc. Detections/Traversals:
    Base (1 report):   2/6   ; FU Alarms/Traversals: 3/30
    Base (3 report):   2/4   ; FU Alarms/Traversals: 6/28
    Adj. (1 report):   0/6 ; FU Alarms/Traversals: 0/30
    Adj. (3 report):   0/4 ; FU Alarms/Traversals: 0/28
Other observations (Short link, data problems, etc., use lines as needed):   The traversal on NW Hwy.

Segment #:   88ef30-88f00c   Direction: E   B
Link Location: (Incident, Upstream, Downstream):   Turn: Through
Inc. Detections/Traversals:
    Base (1 report):   1/5 ; FU Alarms/Traversals: 0/15
    Base (3 report):   0/3 ; FU Alarms/Traversals: 0/13
    Adj. (1 report):   ; FU Alarms/Traversals:
    Adj. (3 report):   ; FU Alarms/Traversals:
Other observations (Short link, data problems, etc., use lines as needed):   The traversal on NW Hwy.

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NU Inc. #: ___15___	NWCD Incident #: __None_____

Date: __11/13/95__	First report: __15:00____	Clear: ___16:00_____

Type: _Short Term Const.___	Inc. Location: NWB Higgins , btw King & ? _____

Incident PV IDs: __2B__ , _____, _____, _____.

Follow-up PV IDs:

Date: _____;   _____, _____, _____, _____.

Date: _____;   _____, _____, _____, _____.

Date: _____;   _____, _____, _____, _____.

Date: _____;   _____, _____, _____, _____.

Use distinct block for each link (and turning movement)

Segment #: _____   Direction: _____.

Link Location: (Incident, Upstream, Downstream) : _____   Turn: _____.

Inc. Detections/Traversals:

Base (1 report): _____ ; FU Alarms/Traversals: _____.

Base (3 report): _____ ; FU Alarms/Traversals: _____.

Adj. (1 report): _____ ; FU Alarms/Traversals: _____.

Adj. (3 report): _____ ; FU Alarms/Traversals: _____.

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: _____   Direction: _____.

Link Location: (Incident, Upstream, Downstream) : _____   Turn: _____.

Inc. Detections/Traversals:

Base (1 report): _____ ; FU Alarms/Traversals: _____.

Base (3 report): _____ ; FU Alarms/Traversals: _____.

Adj. (1 report): _____ ; FU Alarms/Traversals: _____.

Adj. (3 report): _____ ; FU Alarms/Traversals: _____.

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: _____   Direction: _____.

Link Location: (Incident, Upstream, Downstream) : _____   Turn: _____.

Inc. Detections/Traversals:

Base (1 report): _____ ; FU Alarms/Traversals: _____.

Base (3 report): _____ ; FU Alarms/Traversals: _____.

Adj. (1 report): _____ ; FU Alarms/Traversals: _____.

Adj. (3 report): _____ ; FU Alarms/Traversals: _____.

Other observations (short link, data problems, etc.; use lines as needed):

NU Inc. #: ___1.5___	NWCD Incident #: ___None___

Date: ___1 1/13/95___   First report: 15:00   Clear: ___16:00___

Type: ___Short Term Const.___	Inc. Location: ___NWB Higgins, btw King & ?___

Segment #: _____   Direction: _____
Link Location (Incident, Upstream, Downstream): _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short link, data problems, etc., use lines as needed)

Segment #: _____   Direction: _____
Link Location: (Incident, Upstream, Downstream): _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short link, data problems, etc.; use lines as needed)

Segment #: _____   Direction: _____
Link Location: (Incident, Upstream, Downstream) _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (short link, data problems etc., use lines as needed)

NU Inc. #: __16__	NWCD Incident #: _None_

Date: _11/14/95_ First report: __16:30__ Clear: ___19:00___

Type: _Short Term Const._ | Inc. Location: _Hintz, S. Acco Plaza & Old Wolf_

Incident PV IDs: __14__ , _____ , _____ , _____ .

Follow-up PV IDs:

Date: _____; _____ , _____ , _____ , _____ .

Date: _____; _____ , _____ , _____ , _____ .

Date: _____; _____ , _____ , _____ , _____ .

Date: _____; _____ , _____ , _____ , _____ .

Use distinct block for each link (and turning movement)

Segment #: _____ Direction: _____ .

Link Location: (Incident, Upstream, Downstream) : _____ Turn: _____ .

Inc. Detections/Traversals:

　　Base (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Base (3 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: _____ Direction: _____ .

Link Location: (Incident, Upstream, Downstream) : _____ Turn: _____ .

Inc. Detections/Traversals:

　　Base (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Base (3 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: _____ Direction: _____ .

Link Location: (Incident, Upstream, Downstream) : _____ Turn: _____ .

Inc. Detections/Traversals:

　　Base (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Base (3 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (1 report): _____ ; FU Alarms/Traversals: _____ .

　　Adj. (3 report): _____ ; FU Alarms/Traversals: _____ .

Other observations (short link, data problems, etc.; use lines as needed):

NU Inc. #: ___16___	NWCD Incident #: ___None___

Date: ___11/14/95___ First report: ___16:30___ Clear: ___19:oo___

Type: ___Short Term Const.___	Inc. Location: ___Hintz, S. Acco Plaza & Old Wolf___

Segment #: _____ Direction: _____
Link Location: **(Incidcnt, Upstream, Downstream):** _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(Short link, data problems, etc., use lines as needed)**

Segment #: _____ Direction: _____
Link Location : **(Incident, Upstream, Downstream)** _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(Short link, data problems, etc.; use lines as needed)**

Segment #: _____ Direction: _____
Link Location: **(Incident, Upstream, Downstream)** _____ Turn: _____
Inc. Detections/Traversals:
    Base (1 report): _____; FU Alarms/Traversals: _____
    Base (3 report): _____; FU Alarms/Traversals: _____
    Adj. (1 report): _____; FU Alarms/Traversals: _____
    Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(short link, data problems, etc.; use lines as needed)**

NU Inc. #: __17__	NWCD Incident #: EGP955 159 1 (EGF9504823)

Date: __11/16/95__ First report: __18:10__ Clear: __19:09__

Type: __ACPI__ | Inc. Location: NB Elmhurst. Elmhurst & Greenleaf

Incident PV IDs: __11__ , ____ , ____ , ____ .

Follow-up PV IDs:

 Date: __11/20__ ; __0B__ , __14__ , __19__ , ____ .

 Date: ____ ; ____ , ____ , ____ , ____ .

 Date: ____ ; ____ , ____ , ____ , ____ .

 Date: ____ ; ____ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: __90f1a-90d61__ Direction: __NB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__ Turn: __Through__ .

Inc. Detections/Traversals:

 Base (1 report): __2/3__ ; FU Alarms/Traversals: __0/18__ .

 Base (3 report): __1/1__ ; FU Alarms/Traversals: __0/16__ .

 Adj. (1 report): __1/3__ ; FU Alarms/Traversals: __0/18__ .

 Adj. (3 report): __1/1__ ; FU Alarms/Traversals: __0/16__ .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: __890fla-8a5c5e__ Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__ Turn: __Through__ .

Inc. Detections/Traversals:

 Base (1 report): __0/1__ ; FU Alarms/Traversals: __N/A__ .

 Base (3 report): ____ ; FU Alarms/Traversals: ____ .

 Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .

 Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed): No FU traversals.

Segment #: __890fla-a5c28__ Direction: __SB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__ Turn: __Turn__ .

Inc. Detections/Traversals:

 Base (1 report): __0/1__ ; FU Alarms/Traversals: __N/A__ .

 Base (3 report): ____ ; FU Alarms/Traversals: ____ .

 Adj. (1 report): ____ ; FU Alarms/Traversals: ____ .

 Adj. (3 report): ____ ; FU Alarms/Traversals: ____ .

Other observations (short link, data problems, etc.; use lines as needed): No FU traversals.

NU Inc. #: ___17___ | NWCD Incident #: ___EGP955 159 1 (EGF9504823)___

Date: ___11/16/95___ First report: _18: 10_ Clear: ___19:09___

Type: ___ACPI___ Inc. Location: ___NB Elmhurst. Elmhurst & Greenleaf___

Segment #: _890d61-890fla_ Direction: _S___B_
Link Location: **(Incident, Upstrcam, Downstrcam):** _UP l_ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): __0/2_; FU Alarms/Traversals: ___N/A__
   Base (3 report): _____; FU Alarms/Traversals: _____
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations **(short link, data problems, etc., use lines as needed):** No FU traversals.

NU Inc. #: 18	NWCD Incident #: None

Date: 11/16/95	First report: 17:40	Clear: 18:10 (moved to shoulder)

Type: Stalled Truck	Inc. Location: SB Busse, Busse & Mark

Incident PV IDs: 11 , 32 , ____ , ____ .

Follow-up PV IDs:

> Date: 11/20 ; 0B , 14 , 19 , ____ .
>
> Date: ____ ; ____ , ____ , ____ , ____ .
>
> Date: ____ ; ____ , ____ , ____ , ____ .
>
> Date: ____ ; ____ , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: 8a60c6-a6381   Direction: SB .

Link Location: (Incident, Upstream, Downstream) : INC   Turn: Through   .

Inc. Detections/Traversals:

> Base (1 report): 4/8 ; FU Alarms/Traversals: 1/9 .
>
> Base (3 report): 4/6 ; FU Alarms/Traversals: 3/7 .
>
> Adj. (1 report): 2/8 ; FU Alarms/Traversals: 1/9 .
>
> Adj. (3 report): 2/6 ; FU Alarms/Traversals: 0/7 .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: 8a5dff-8a60c6   Direction: SB .

Link Location: (Incident, Upstream, Downstream) : UP1   Turn: Through .

Inc. Detections/Traversals:

> Base (1 report): 1/8 ; FU Alarms/Traversals: 0/18 .
>
> Base (3 report): 0/6 ; FU Alarms/Traversals: 0/16 .
>
> Adj. (1 report): 2/8 ; FU Alarms/Traversals: 0/18 .
>
> Adj. (3 report): 1/6 ; FU Alarms/Traversals: 0/16 .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: a638l-8a63e0   Direction: SB .

Link Location: (Incident, Upstream, Downstream) : DN1   Turn: Turn .

Inc. Detections/Traversals:

> Base (1 report): 1/2 ; FU Alarms/Traversals: 11/15 .
>
> Base (3 report): ____ ; FU Alarms/Traversals: 13/13 .
>
> Adj. (1 report): 0/2 ; FU Alarms/Traversals: 0/15 .
>
> Adj. (3 report): ____ ; FU Alarms/Traversals: 0/13 .

Other observations (short link, data problems, etc.; use lines as needed): Short link combined; several erratic CTTs in both Inc. & FU traversals.

NU Inc. #: ___18___	NWCD Incident #: ___None___

Date: ___1 l/16/95___ First report: 17:40	Clear: ___18: 10 (moved to shoulder)___

Type: ___Stalled Truck___	Inc. Location: ___SB Busse. Busse & Mark___

Segment #: ___126c5d-a60c6___ Direction: N B
Link Location: (Incident, Upstream, Downstream): ___INC___ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): ___0/6___; FU Alarms/Traversals: ___N/A___
   Base (3 report): ___0/4___; FU Alarms/Traversals: _____
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short link, dataproblems, etc.; use lines as needed): ___No FU traversals.___

Segment #: ___8a673a- 126c5d___ Direction: N B
Link Location: (Incident, Upstream, Downstream): ___UP 1___ Turn: ___Through___
Inc. Detections/Traversals:
   Base (1 report): ___0/6___; FU Alarms/Traversals: ___N/A___
   Base (3 report): ___0/4___; FU Alarms/Traversals: _____
   Adj. (1 report): _____; FU Alarms/Traversals: _____
   Adj. (3 report): _____; FU Alarms/Traversals: _____
Other observations (Short. link. data problems, etc., use lines as needed): No FU traversals

NU Inc. #: __19__	NWCD Incident #: AHP9536477

Date: __08/22/95__   First report: __18:24__   Clear: __18:49__

Type: __Motorist Assistance__	Inc. Location: Dundee & Wilke

Incident PV IDs: __1B__ , __11__ , _____ , _____ .

Follow-up PV IDs:

        Date: __08/11__ ;   __42__ , __50__ , _____ , _____ .
        Date: __08/14__ ;   __69__ , __5C__ , __3E__ , __17__ .
        Date: __08/15__ ;   __37__ , __32__ , __10__ , __59__ , __2B__ , __19__ ,
        Date: __08/16__ ;   __11__ , __17__ , __19__ , __50__ , __0B__ , __0D__ , __1A__ ,
        Date: __08/21__ ;   __0B__ , __14__ , __19__ , _____ .
        Date: __08/23__ ;   __0A__ , __1B__ , _____ , _____ .
        Date: __08/24__ ;   __10__ , __2B__ , __57__ , _____ .
        Date: __08/25__ ;   __5C__ , __59__ , __10__ , _____ .
        Date: __11/07__ ;   __11__ , __1B__ , _____ , _____ .
        Date: __11/08__ ;   __11__ , __52__ , _____ , _____ .
        Date: __11/15__ ;   __16__ , __52__ , _____ , _____ .
        Date: __11/16__ ;   __16__ , _____ , _____ , _____ .
        Date: __11/17__ ;   __17__ , _____ , _____ , _____ .

Use distinct block for each link (and turning movement)

Segment #: __8cb09-8cb0a__   Direction: __WB__ .
Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .
Inc. Detections/Traversals:
       Base (1 report): __4/8__ ; FU Alarms/Traversals: __1/9__ .
       Base (3 report): __4/6__ ; FU Alarms/Traversals: __3/7__ .
       Adj. (1 report): __2/8__ ; FU Alarms/Traversals: __1/9__ .
       Adj. (3 report): __2/6__ ; FU Alarms/Traversals: __0/7__ .
Other observations (short link, data problems, etc.; use lines as needed):

Segment #: 8cb07-8cb09   Direction: __WB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .
Inc. Detections/Traversals:
       Base (1 report): __1/3__ ; FU Alarms/Traversals: __0/89__ .
       Base (3 report): __1/1__ ; FU Alarms/Traversals: __0/87__ .
       Adj. (1 report): __0/3__ ; FU Alarms/Traversals: __0/89__ .
       Adj. (3 report): __0/1__ ; FU Alarms/Traversals: __0/87__ .
Other observations (short link, data problems, etc.; use lines as needed):

NU Inc. #: ___19___ | NWCD Incident #: ___AHP9536477___

Date: ___08122195___ First report: ___18:24___ Clear: ___18:49___

Type: __Motorist Assistance__ | Inc. Location: ___Dundee & Wilke___

Segment #: ___88cbOa-88cb09___ Direction: ___E B___
Link Location: (Incident, Upstream, Downstream): ___INC___ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___0/l___ ; FU Alarms/Traversals: _7/64_
    Base (3 report): _____ ; FU Alarms/Traversals: _5/62_
    Adj. (1 report): _____ ; FU Alarms/Traversals: _____
    Adj. (3 report): _____ ; FU Alarms/Traversals: _____
Other observations (Short link, data problems, etc., use lines as needed): __Short link? Signal?__

Segment #: ___89d42f-88cb0a___ Direction: E B
Link Location (Incident, upstream, Downstream): ___UP1___ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___0/l___ ; FU Alarms/Traversals: __0/70__
    Base (3 report): _____ ; FU Alarms/Traversals: __0/68__
    Adj. (1 report): _____ ; FU Alarms/Traversals: _____
    Adj. (3 report): _____ ; FU Alarms/Traversals: _____
Other observations (Short link, data problems etc., use lines as needed)

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NU Inc. #: __20__	NWCD Incident #: AHP9536477

Date: 08/24/95	First report: 15:29	Clear: 16:53

Type: ACPD	Inc. Location: Higgins & Lively

Incident PV IDs: 17 , 14 , ____ , ____ .

Follow-up PV IDs:
      Date: 11/07 ;   16 , 09 , 52 , 5A .
      Date: 11/08 ;   19 , 16 , 0B , ____ .
      Date: 11/08 ;   19 , ____ , ____ , ____ .
      Date: 11/14 ;   09 , 2B , ____ , ____ .
      Date: 11/15 ;   57 , 5A , ____ , ____ .
      Date: 11/16 ;   14 , 11 , 1B , ____ .
      Date: 11/17 ;   14 , 5A , 2B , ____ .
      Date: 11/21 ;   14 , ____ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: 890406-890458   Direction: __SEB__ .
Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __0/2__ ; FU Alarms/Traversals: __0/61__ .
      Base (3 report): _____ ; FU Alarms/Traversals: __0/59__ .
      Adj. (1 report): __0/2__ ; FU Alarms/Traversals: __1/61__ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: __0/59__ .
Other observations (short link, data problems, etc.; use lines as needed):

Segment #: 890313-890406   Direction: __EB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __0/2__ ; FU Alarms/Traversals: __0/69__ .
      Base (3 report): _____ ; FU Alarms/Traversals: __0/67__ .
      Adj. (1 report): __0/2__ ; FU Alarms/Traversals: __1/69__ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: __0/67__ .
Other observations (short link, data problems, etc.; use lines as needed):

Segment #: 8cb07-8cb09   Direction: __WB__ .
Link Location: (Incident, Upstream, Downstream) : __UP1__   Turn: __Through__ .
Inc. Detections/Traversals:
      Base (1 report): __1/2__ ; FU Alarms/Traversals: __0/60__ .
      Base (3 report): _____ ; FU Alarms/Traversals: __0/58__ .
      Adj. (1 report): __2/2__ ; FU Alarms/Traversals: __1/60__ .
      Adj. (3 report): _____ ; FU Alarms/Traversals: __0/68__ .
Other observations (short link, data problems, etc.; use lines as needed):

NU Inc. #: __21__	NWCD Incident #: <u>AHP9549518</u>

Date: __11/16/95__	First report: __13:19__	Clear: __16:04__

Type: __LMAL__	Inc. Location: <u>Algonquin & Arlington Hts</u>

Incident PV IDs: __1B__ , __09__ , __32__ , __14__ .

Follow-up PV IDs:

    Date: __11/07__ ;   __0B__ , ____ , ____ , ____ .
    Date: __11/08__ ;   __0A__ , __0B__ , ____ , ____ .
    Date: __11/09__ ;   __1B__ , __11__ , __19__ , __57__ .
    Date: __11/13__ ;   __0B__ , __2B__ , ____ , ____ .
    Date: __11/14__ ;   __2B__ , __32__ , ____ , ____ .
    Date: __11/15__ ;   __0B__ , __0D__ , ____ , ____ .
    Date: __11/17__ ;   __1B__ , __4B__ , __09__ , ____ .
    Date: __11/21__ ;   __19__ , __44__ , ____ , ____ .

Use distinct block for each link (and turning movement)

Segment #: <u>ce8a8-8f78c</u>	Direction: __WB__ .

Link Location: (Incident, Upstream, Downstream) : __INC__   Turn: __Through__ .

Inc. Detections/Traversals:

    Base (1 report): __3/3__ ; FU Alarms/Traversals: __6/54__ .
    Base (3 report): __1/1__ ; FU Alarms/Traversals: __4/52__ .
    Adj. (1 report): __3/3__ ; FU Alarms/Traversals: __0/54__ .
    Adj. (3 report): __1/1__ ; FU Alarms/Traversals: __0/52__ .

Other observations (short link, data problems, etc.; use lines as needed):

Segment #: <u>8f78c-8fc60</u>	Direction: __NWB__ .

Link Location: (Incident, Upstream, Downstream) : __DN1__   Turn: __Through__ .

Inc. Detections/Traversals:

    Base (1 report): __0/5__ ; FU Alarms/Traversals: __3/15__ .
    Base (3 report): __0/3__ ; FU Alarms/Traversals: __0/13__ .
    Adj. (1 report): __0/5__ ; FU Alarms/Traversals: __0/15__ .
    Adj. (3 report): __0/3__ ; FU Alarms/Traversals: __0/13__ .

Other observations (short link, data problems, etc.; use lines as needed): <u>Short link combined.</u>

NU Inc. #: ___21___	NWCD Incident #: ___AHP95495 18___

Date: ___1 l/16/95__ First report: _13: 19___ Clear: _____16:04_____

Type: ___LMAL___	Inc. Location: ___Algonquin & Arlington Hts.___

Segment #: ___88f78c-8ce8a8___   Direction: __S__ __B__
Link Location: (Incident, Upstream, Downstream) __I N C__ Turn: ___Through___
Inc. Detections/Traversals:
    Base (1 report): ___3/7___ ; FU Alarms/Traversals: ___l/34___
    Base (3 report) : ___4/5___ ; FU Alarms/Traversals: ___3/32___
    Adj. (1 report): ___0/7___ ; FU Alarms/Traversals: ___2/34___
    Adj. (3 report): ___0/5___ ; FU Alarms/Traversals: ___0/32___
Other observations (short link, data problems, etc.;   use lines as needed):

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